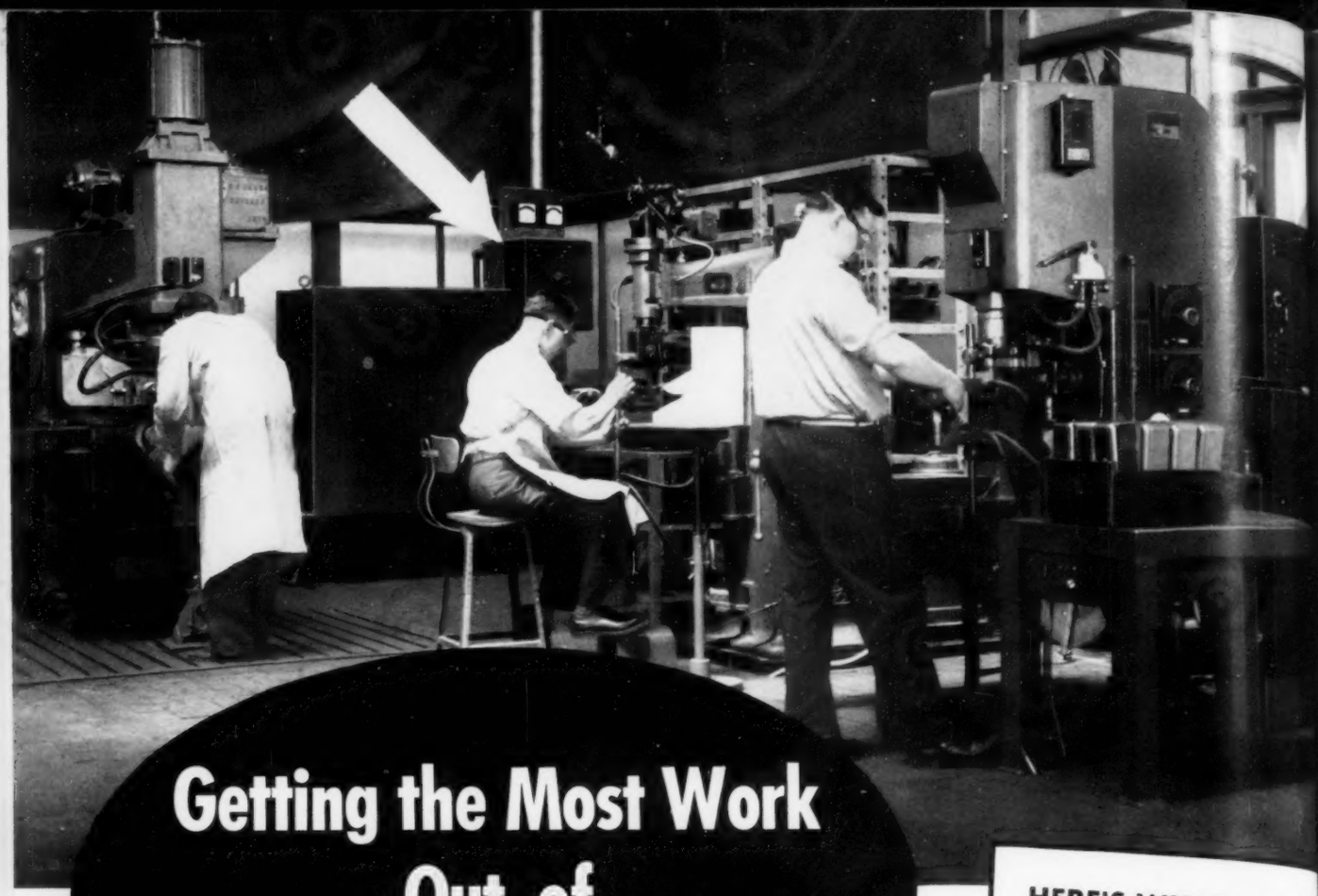
The Welding Journal

MARCH, 1939

The Journal of the American Welding Society



Getting the Most Work Out of Welding Machines

MAXIMUM AVAILABILITY IS ASSURED BY BREAKERS

Put G-E air circuit breakers on guard to protect the electric circuits supplying your welding machines—to interrupt damaging short circuits instantly and safely—to restore service immediately with no time out for fuse replacement—and thus to increase machine availability.

G-E air circuit breakers, when controlled by the automatic action of other devices, can also provide protection against undesirable operating conditions, such as low voltage, faulty timing, and no water flow in transformers.

One of the big features of G-E air circuit breakers: their adjustable overcurrent trip can be set to open the breaker just above the during-welding current value, and below the safe limit for the welding equipment.

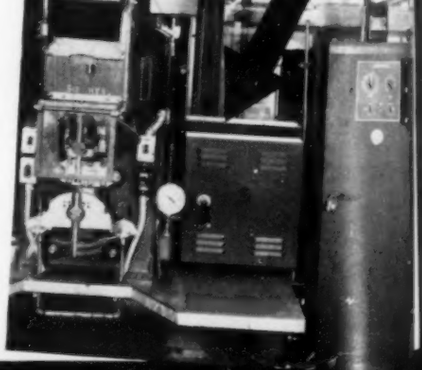
Learn More about Them

—about the arc quencher, which makes possible the interruption of dangerous short circuits before a watch ticks twice—and other notable features described in Leaflet GEA-2997. Ask for a copy. General Electric, Schenectady, N. Y.

HERE'S WHAT A WELDING ENGINEER SAYS:

"These G-E air circuit breakers certainly have protected the welding equipment against damaging overcurrents. On more than one occasion while welding aluminum, the breaker opened so fast that only 1/4 of full-depth indentation was made on the aluminum when the current exceeded the trip setting of the breaker."

HERE'S ONE OF HIS G-E BREAKERS



GENERAL ELECTRIC

890-7

The American Welding Society Journal

W. SPRARAGEN, Editor

Published for the Advancement of the Science and Art of Welding

OFFICERS—1938–1939
President, H. C. BOARDMAN
First Vice-President, Col. G. F. JENKS
Second Vice-President, TURNER C. SMITH
Treasurer, C. A. McCUNE
Secretary, M. M. KELLY
Technical Secretary, W. SPRARAGEN

VOLUME 18 NUMBER 3

MARCH 1939

Divisional Vice-Presidents
W. F. HESS, New York & New England
W. W. PETRY, Middle Eastern Division
K. L. HANSEN, Middle Western Division
K. V. KING, Pacific Coast
W. J. SANNEMAN, Southern

CONTENTS

TECHNICAL PAPERS, ITEMS AND REPORTS

Low Temperature Brazing, by R. N. Chapin 137
Large Welded Elevated Water Tanks, by H. C. Boardman 141
Arc Welding in Aircraft, by Ralph H. Upson 143
Automatic Carbon Arc Welding in the Automotive Industry, by F. M. Maichle 147
The Relation of the Engineer to the Welder and the Foundryman, by T. B. Jefferson 151
The Teaching of Welding and Heat Treating as Applied to Engineering, by O. M. Harrelson 153
Welded Steel Pipe for the City of Toronto Water Works Extension, by Carl R. Whittemore 156
Carburized Welds, by E. J. Wellauer and G. C. Doehler 163
Data on Spot Welding of 18–8 Stainless Steel to Yellow Brass, by F. R. Hensel, E. I. Larsen and E. F. Holt 167
Welding General Hospital Building, Boston, by J. Theodore Whitney 175
Highway Department Welding Survey, by Clark A. Dunn 176

COVER

A modern 12-room residence built with arc-welded steel framing at Wichita Falls, Texas. *Photo Courtesy Lincoln Electric Co.*

SOCIETY AND RELATED ACTIVITIES

The Place of an Engineering Society 177
Notice Regarding Code 1—Part A ... 177
The Engineers' Manual 178
Handbook for Welded Structural Steelwork 178
NEMA Transformer Standards 178
The Principles of Metallographic Laboratory Practice, by George L. Kehl 178
Welded Presses Are Key Machines in Preparation of Scrap Iron 180
Maryland Casualty Conference 180
Tentative Specifications for Spiral Welded Steel or Iron Pipe 180
Temperature Symposium 180
Arc Welded Steel Frame in 12-Room Residence 182
Welding Goes to the Tournament of Roses Parade 184
Delivered During a Snow Storm 184
An All-Welded Pressure Vessel 184
New Orleans A. S. M. E. Spring Meeting 186
Torch Machine 186
Supplying Power for Single-Phase Resistance Welders 186
New Products 188
Eleventh Welding Conference 190
List of New Members 192
Employment Service Bulletin 194
Section Activities 195
Obituary 197

WELDING RESEARCH SUPPLEMENT

Welding Chromium and Chromium-Nickel Corrosion and Heat Resisting Steels, by W. Spraragen and G. E. Claussen 65
Physical Properties of the Iron-Nickel Alloys Formed in the Welding of Nickel-Clad Steel, by W. G. Theisinger and F. G. Flocke 108

ISSUED MONTHLY

Copyright, 1939, by the American Welding Society

Subscription $5.00 per year in United States and possessions; $5.50 in Canada and Mexico; Foreign Countries $7.00. Single copies, non-members $.75; Special issues October and December $1.00; members 50 cents.
Entered as second-class matter January 15, 1932, at the post-office at Easton, Pa., under the Act of March 3, 1879.
PUBLICATION OFFICE
20th & Northampton Streets, Easton, Pa.
EDITORIAL AND GENERAL OFFICES
33 West 39th St., New York, N. Y.

The Society is not responsible for any statement made or opinion expressed in its publications. Permission is given to reprint any article after its date of publication provided proper credit is given.

Everything

for Oxy-Acetylene Welding and Cutting

PROGRESS in the art of working metals requires a convenient and dependable source of acetylene, calcium carbide, oxygen, and welding and cutting apparatus and supplies. Whether you use the oxy-acetylene process for welding, cutting, flame-hardening, hard-facing, flame-softening, or steel conditioning, you can obtain promptly all the necessary products and service through The Linde Air Products Company.

Gases— Linde Oxygen is sold throughout the nation in gray-and-green cylinders. Each cylinder contains 110 cubic feet or 220 cubic feet of oxygen at a pressure of 2,000 pounds per square inch. All Linde Oxygen—whether for industrial or therapeutic use—is the same high and uniform quality.

Prest-O-Lite Dissolved Acetylene is produced from Union Carbide. For welding and cutting, it is sold in portable black steel cylinders having rated capacities of 100 cubic feet and 300 cubic feet of acetylene. For use with Prest-O-Lite appliances—heating torches, soldering irons and portable lights—Prest-O-Lite Dissolved Acetylene is sold in small steel tanks of 10- and 40-cubic feet capacity.

Calcium Carbide—Union Carbide is packed in 100-pound blue-and-gray drums. Because of its uniform quality, high gas yield, accurate sizing, and careful packing, it has been recognized as a standard of excellence for over forty years. Union Carbide, an electric furnace product, is crushed and screened to all standard generator sizes.

Carbic Processed Carbide is high-grade calcium carbide, specially treated and compressed into cakes for use in Carbic acetylene generators and Carbic acetylene flood lights. The most frequently used size of Carbic cakes is No. 20. The orange drum of 40 cakes weighs 100 pounds.

Union Carbide and Carbic Processed Carbide are readily available from warehouses, jobbers, and distributors throughout the country.

Apparatus— Oxweld, Prest-O-Weld, and Purox lines of welding and cutting blowpipes, regulators, manifolds, and outfits; Oxweld cutting machines; Oxweld and Carbic acetylene generators; and the complete Oxweld line of accessories, welding rod, and supplies—all are sold by Linde.

Service— The Linde service organization brings to users of the oxy-acetylene process practical field experience, based on comprehensive research and development facilities. This process service is available from field engineers—also through technical books, booklets, magazine articles, motion pictures, and in numerous other ways.

The words "Linde," "Union," "Prest-O-Lite," "Prest-O-Weld," "Purox," "Oxweld" and "Carbic" are trade-marks of Units of Union Carbide and Carbon Corporation.

The Linde Air Products Company

Unit of Union Carbide and Carbon Corporation

UCC

New York and Principal Cities · In Canada: Dominion Oxygen Company, Limited, Toronto

LINDE OXYGEN · PREST-O-LITE ACETYLENE · OXWELD APPARATUS AND SUPPLIES · UNION CARBIDE

Welding Journal

VOLUME 18, No. 3 MARCH 1939

LOW TEMPERATURE BRAZING*

By R. N. CHAPIN†

THE term "Low Temperature Brazing" is comparatively new in the welding industry. Because of this, it is advisable to look into the meaning of this term and define it so our understanding of it may be clear and definite.

Welding, as a process, is well known to all who work with almost any form or type of metal. There are many definitions of welding and in all of them it is clearly stated that the parts being joined are heated to a temperature at which they become plastic or molten. In other words, a fusing action takes place.

Brazing, on the other hand, is the joining of metallic parts without fusion of the base metals. The term is possibly a contraction of the word "Brassing" which was used some years ago when two ferrous parts were joined by placing a strip of brass between them and then heating in a forge to a temperature sufficient to make the brass run. Today we think of brazing in connection with the use of brass, tobin or manganese bronze, and other similar filler rods when joining cast-iron steel and copper as these are the metals usually joined by this method. The filler rod in this process melts at a lower temperature than the base metals being joined.

The spelter brazing rods customarily used have a flow temperature of about 1650° F. This may vary 50° F. plus or minus depending upon the composition of the rod. This temperature is well below that required for welding, and it is this difference that is one definite advantage in the use of the brazing process over that of welding. It means that the parts being joined do not have to be heated to as high a temperature, thus saving time, gases and the possibility of damage by distortion, etc.

The low temperature brazing alloys now being used will flow freely in the range of 1175–1532° F. A comparison of this temperature group with that of other welding, brazing and soldering temperatures is shown in Fig. 1. Perhaps it would be more correct to refer to them as lower rather than low temperature alloys for they cover the upper part of the range between soft soldering and braze welding. However, at the present time there is no generally known or used high strength brazing alloy that flows freely under 1175° F.

There are three well established low temperature brazing alloys on the market today. These may be divided into two general classes, one having two alloys which are to be used only on copper and the copper base metals, while the second has but one for use on iron, steel, nickel and other ferrous as well as the non-ferrous metals mentioned above.

With this general classification understood, let us see what elements go to make up these alloys. In the first group which is to be used only on the non-ferrus alloys, one is composed of 93% copper and 7% phosphorus while the second has 80% copper, 15% silver and 5% phosphorus. The single alloy in the second group contains 50% silver with the balance made up of copper zinc and cadmium.

Since two of these low temperature brazing alloys contain silver, it is only natural for one to say, "Why they are only silver solders." That is absolutely true. They are silver solders for any alloy containing more than 10% silver is known by this name. However, the term Low Temperature Brazing Alloy has been used for the last few years as a substitute for this well-known term, Silver Solder. In the first place, these two silver bearing alloys melt at lower temperatures than any of the other silver solders and in the second place, the name was rather misleading. The average person knows that jewelers and silversmiths use silver solders, but the idea of industry in general using these precious metal alloys was rather fantastic.

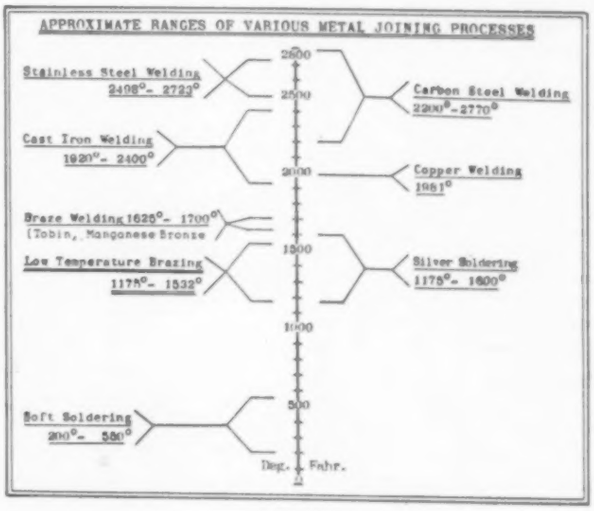


Fig. 1

* Presented before Los Angeles Section A. W. S.
† Air Reduction Sales Co., Applied Engineering Dept.

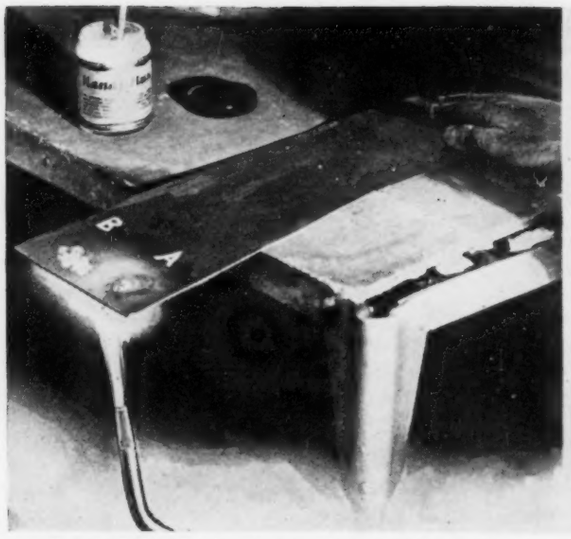


Fig. 2—A Simple Heat Test for Fluxes and Brazing Alloys

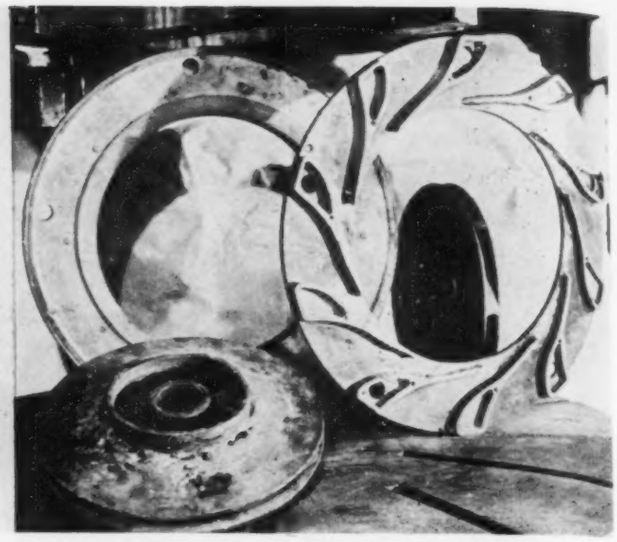


Fig. 3—Parts of Bronze Centrifugal Pump Vanes on Outer Rim and Sides of Rotor to Be Built Up Where Worn with Phos.-Copper to Resist Wearing Action of Sand in Water

It was extremely difficult to introduce new operations involving the use of these alloys. The prospective customer would invariably say "No" and would not even consider a demonstration or trial of these "expensive solders." This attitude is not hard to understand for it does seem strange that a precious metal alloy can be used economically in such industries as ornamental brass or bronze work, heating and plumbing, metal furniture fabrication, shipyards, railroads, refrigerator, automotive, etc. Furthermore, the fact that one of these alloys, that containing 50% silver, is sold by the Troy ounce, a precious metal unit of weight, added to the sales resistance.

Since its introduction, the term Low Temperature Brazing has become widely used so that today it has a very definite place with welding, brazing and soldering. The silver bearing alloys have the same composition but as silver solders they were not even considered while by their new name they have been tried and in the majority of cases, accepted.

It is not possible in the allotted space to cover all the various kinds of jobs that are being done today with these alloys. The most we can hope to do is to point out some of the outstanding as well as the more common production operations with which we are familiar.

One important fact must be borne in mind. These alloys are not a panacea for all difficult problems in joining metals. There are some conditions which must be met before they can be used efficiently or effectively. Perhaps the most important requirement is proper joint design. As deposited in a joint when using the oxyacetylene torch or some other method of heating, the alloy is in a cast condition. Because of this, the alloy should resist shear rather than a direct tensile stress. Consesequently, butt joints are generally avoided. In ornamental iron or brass work where stresses are usually not as important as appearance, butt joints can safely be used but it is advisable to bear in mind that in all other cases, a lap, scarf, sleeve or some similar type of joint is recommended.

Mr. R. H. Leach* has made exhaustive tests which show that joint separation has a definite bearing on strength of joints. He found that clearances on the order of 0.0015–0.002 inch developed greatest strength when using the 50% silver content alloy on stainless steel. To be sure, these were butt joints as separations could be measured more readily but the same principle will apply to the lap type.

The results of these tests do give us very important data that can be applied to every-day commercial use. The brazing alloys actually mix or alloy with the base metals along each surface. Thus, with the close separation mentioned above, the alloying area on one face will extend to the alloying area on the other.

The actual mechanics of making a sound joint are very simple. It is much the same as soft soldering. The surfaces being joined must be absolutely free of any oxide, scale and grease. This is easily accomplished by mechanical cleaning with sand paper, emery-cloth, steel wool, etc. Chemically cleaning by pickling or some similar

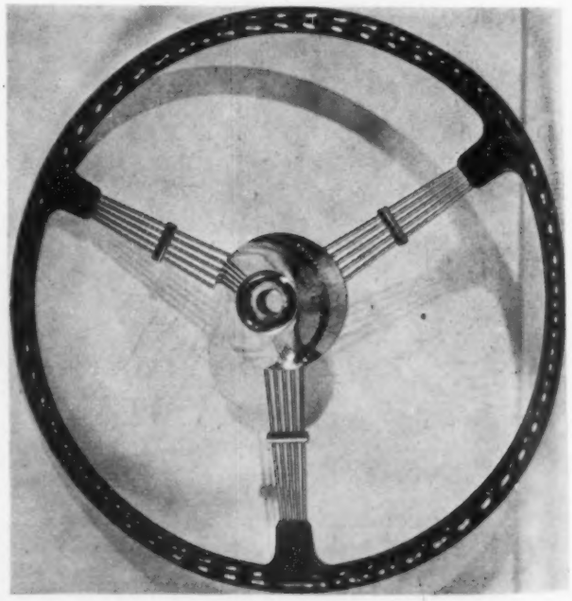


Fig. 4—Auto Steering Wheel—Mild Steel Rim Brazed to Stainless Steel Spokes with Easy-Flo Before Plastic Is Molded in Place

*R. H. Leach—In paper "When and How Silver Solders are Used"—A. W. S. 10/36.

Fig. 5—Tubular Heat Exchanger Copper Tubing Brazed to Brass Castings with Phos.-Copper

method is effective in removing heavy oxides, grease, etc., but the surfaces so cleaned should be well rinsed with clean water.

We have discussed joint preparation in so far as cleaning and alignment are concerned. Before the heat is applied, there is another important factor to consider. Most metals oxidize when they are heated and it is necessary to provide some means of overcoming this action, for as is mentioned above, the brazing alloy is most effective when applied to clean metal.

The majority of brazing operations involving the use of low temperature brazing alloys are done on non-ferrous metals, that is, on copper or the copper base alloys. Copper oxidizes readily as its temperature rises. At the brazing temperature which may range from 1175° to 1500° F., this oxidation is very pronounced and either cuprous or cupric oxide is formed on the surface of the metal. This surface coating has to be prevented or removed before the brazing alloy is applied. This is accomplished by a flux which dissolves or deoxidizes this scale or coating. Potassium Borate, Sodium Borate, Boric Acid or a combination of these compounds will dissolve the oxides and leave a clean surface.

The function of a flux is three-fold:

1. It offers a protective coating which tends to prevent oxidation during heating operations.
2. It dissolves any oxides that may form.
3. It assists in the free flowing of the brazing alloy.

The first two functions have been described in the above paragraph. If a protective coating of flux is applied to the surfaces being heated, oxidation largely will be eliminated. The flux is not fully active until it is in the molten state. For this reason, it is important to select and use a flux that will be active at the temperature at which the brazing alloy is entirely liquid.

The third function, that of assisting the alloy to flow, is equally important. Capillary attraction is the principal force causing solders or brazing alloys to flow and as the flux flows ahead of and is displaced by them, it is only reasonable to assume that an entirely clean surface is provided for the bonding of bare metals and brazing alloy.

There is one condition that does not require the use of a flux. On clean copper to copper joints, either the copper-phosphorous or the silver copper-phosphorous alloy may be applied without flux. The reason for this is quite understandable—both these alloys contain phosphorous which in itself is an active deoxidizing agent. This element reacts with any cuprous or cupric oxide present in the joint and readily dissolves it. However, when brazing brass, bronze, etc., the oxides formed by the heating are much more complex due to the presence of zinc, tin and other alloying elements. These oxides require a stronger fluxing action than the phosphorus can provide and a flux must be supplied to aid in the proper cleaning of the surfaces to be joined.

More or less the same condition exists when brazing steel, nickel, etc., with the high silver content alloy. The chrome oxides formed when heating stainless steel are more difficult to dissolve or remove than the copper oxides, and for this reason, a stronger flux is required. One with a fluoride base has proved to be very effective under these circumstances.

With the above mentioned conditions to overcome, it seemed advisable to have a flux that will be an active cleansing agent on all types of metals. Such a flux is on the market today and while the fluoride present in it may not be entirely necessary on copper, brass or bronze, it is effective where nickel, stainless steel and other ferrous alloys are to be brazed. It is completely fluid and active at 1100° F. Knowledge of this melting temperature is quite helpful to operators, for when the flux melts, it gives them a good indication that the joint is nearly up to the proper brazing point.

Fluxes are best applied when in paste form and where needed with a felt dauber or a small paint brush. When first heated, the water boils out leaving the powder or crystalline form on the work. With continued heating, this starts to melt at which time the deoxidizing action has started.

The brazing alloy whether it be in rod or wire form, should be coated with flux also to prevent its oxidation as it becomes heated. Dipping the alloy in the flux jar will afford satisfactory protection but it may be considered more advisable in some instances to paint on the flux with the brush or dauber.

We have spent considerable time on this subject of fluxing. In our estimation it is a very important factor in successful low temperature brazing or in spelter brazing too, for that matter. In tracing down reports of trouble on brazing operations, the underlying cause of the trouble very often proves to be careless fluxing. The average operator knows that fluxes have to be used, just as he knows that he must open the acetylene valve first when lighting his torch. It would not be necessary to go into great detail or theory as to why fluxes are used, but it might be helpful to him if the foreman or superintendent took a minute or so to explain that oxide scale has to be broken up and dissolved before he will secure a sound joint.

An illustration of an interesting and convincing demonstration of the effectiveness of fluxes is shown in Fig. 2.

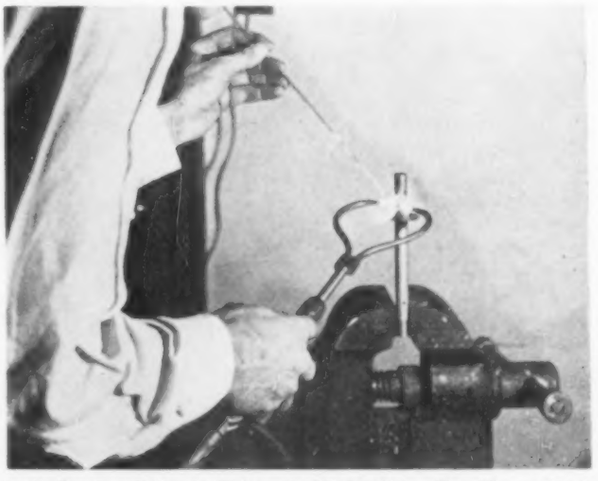


Fig. 6—Brazing Collar to Tube with Sil-Fos Using Two Flame Tip for Rapid Uniform Heating

A plate is extended over the side of a welding table so it can be heated from beneath. It is suggested that copper be used for its high thermal conductivity will tend to create a uniform temperature over a considerable area. Samples of fluxes can be heated to determine comparative melting points and deoxidizing characteristics. Likewise brazing alloy flowing points can be compared.

Nothing has been said here of specific operations involving the low temperature brazing alloys. Their use on the household electric and gas refrigerators is now taken for granted. The automotive industry is utilizing them in an increasing number of operations. Here, as in many other industries, production must have maximum efficiency to maintain moving assembly lines. These alloys, although more expensive than steel or bronze-welding and brazing rods or arc-welding wire, require less time for heating, and have no finishing costs. With properly designed joints, very little alloy is used and brazing time is cut to a minimum. As a matter of fact, the least amount of filler metal that will wet the joint surfaces and fill the voids, the stronger the joint.

A comparative test was recently made in a steel bed manufacturing plant. Tobin bronze (60% copper, 39% zinc, 1% tin) had been satisfactorily used for some time on tubing connections of the head and foot board. However, it was necessary to tack weld the tubing ends with steel before brazing as the heat of this latter operation caused sufficient expansion to crack the brazed joint on subsequent cooling. The 50% silver brazing alloy was used on one head board for a comparison of costs.

Two operations were eliminated—the tack welding with steel and long tedious grinding to remove excess bronze (for appearance). The low temperature alloy penetrated into the joint and formed a neat fillet that required no grinding. The saving in labor on this one operation more than compensated for the materially higher cost of the brazing alloy.

In general, it may be said of all three low temperature brazing alloys that although their cost is somewhat higher than bronze, the savings in labor costs offset this factor in many cases. Speed of production because of lower heat required and elimination of clean-up time are the two major reasons why so many varied types of industries are using these alloys in increasing quantities.

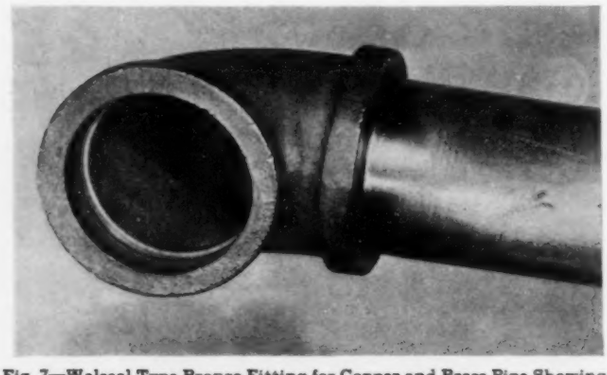


Fig. 7—Walseal Type Bronze Fitting for Copper and Brass Pipe Showing Sil-Foe Annular Insert in Groove Cut in Fitting

Fig. 8—Sil-Foe Brazing Mitered Joint in Government Bronze Casting

One interesting and perhaps little known quality of the copper-phosphorous alloy is its hardness which is 85 on the Rockwell "B" scale. The electrical industry uses it for building up worn switch or controller contacts. The steel mills are using it to reclaim brass guides for hot and cold strip mills. They find that it will outwear two or three of the older type guides and the cost is about one third that of a new guide.

Figure 3 shows an application of this type. The rotor and the diffuser vanes of a centrifugal pump were worn away by the sand in the water. These were built up with the copper-phosphorous alloy. The low heat required minimized the danger of distortion.

Some other interesting applications of the alloys are shown in the accompanying illustrations. Figure 4 shows the banjo type steering wheel used on a popular make of automobile. The stainless steel spokes are brazed with the 50% silver alloy to the mild steel rim before the plastic is molded in place. Figure 5 is a common type of heat exchanger brazed with the copper-phosphorous alloy. Figure 6 shows a two flame tip being used for brazing a collar on copper tubing. This distribution of heat brings the parts up to the brazing temperature in about half the time required by a single flame tip. Incidentally, annealed copper is used so that the tip can be bent to fit a particular operation.

Figure 7 shows a bronze fitting adapted for use with the silver-copper-phosphorous alloy. An insert of this material is placed in a machined groove in the fitting. High strength joints that can operate at temperatures in the vicinity of 1000° F. can be made on brass pipe and copper pipe or tubing. Figure 8 shows an operator making up a joint on a cast bronze lamp post base. Low temperature brazing alloys are used to good advantage on this type of work for they penetrate deeply and can be worked from the reverse side thus saving finishing costs.

LARGE WELDED ELEVATED Water Tanks*

By H. C. BOARDMAN†

NEED FOR TANKS

LARGE storage tanks at strategic points reduce number of pumping units required, provide ample water supply for peak demands at a practically uniform pressure and put an almost constant load on pumping equipment. It is desirable that such tanks be of shallow construction to hold main pressure and pump load constant. Demand for such equipment is for large diameters and small depth varying from 35 to 25 feet and frequently less and is met by the development of the so-called *radial cone* tank, deriving its name from the bottom construction, which consists of a number of radial troughs, each a cone segment, sagging down between and supported on an equal number of radial girders which, in turn, are carried by one or more circles of posts and a central cylinder or riser.

The sketch below indicates a radial cone tank, and, on each side of it, three tanks of old conventional types of smaller diameter and greater depth. The three on the left have the same height to the water line as the radial cone tank, with the storage capacity below the water line entirely wasted, assuming the effective depth is that of the radial cone tank. The three on the right show how those on the left would have to be rebuilt to have the same capacity as the radial cone tank above the water level of the latter. The effective capacities of the three on the left, in the same range of the radial cone tank, are evidently much less than the capacity of the latter. The ranges of head of the three on the right are clearly much more than that of the radial cone vessel.

DESIGN OF TANKS

First, the design loads and stresses must be established. The structure must withstand the stresses induced by:

(*a*) The weight of steel at 489 lb. per cubic foot.
(*b*) The water weight at $62\frac{1}{2}$ lb. per cubic foot.
(*c*) The weight of snow, a fair value of which is 25 lb. per square foot of horizontal projection of the tank.
(*d*) Wind forces, which are commonly assumed to be due to a straight wind. While specifications vary widely, common values are about 20 lb. per sq. ft. of vertical projection of the tank and central cylindrical riser, and 50 lb. per linear foot of each column.

Usually A. S. T. M.-A7 steel is used for structural shapes, and A. S. T. M.-A7 or -A10 steel for the tank and riser plates. For these materials, permissible unit stresses are:

COLUMNS

Allowable stress, lb. per sq. in. $= XY$ (May be increased 25% for wind plus other stresses)

$$Y = 1 \text{ for } \frac{l}{r} \leqslant 60$$

$$Y = \frac{21600}{18000 + \left(\frac{l}{r}\right)^2} \text{ for } \frac{l}{r} > 60$$

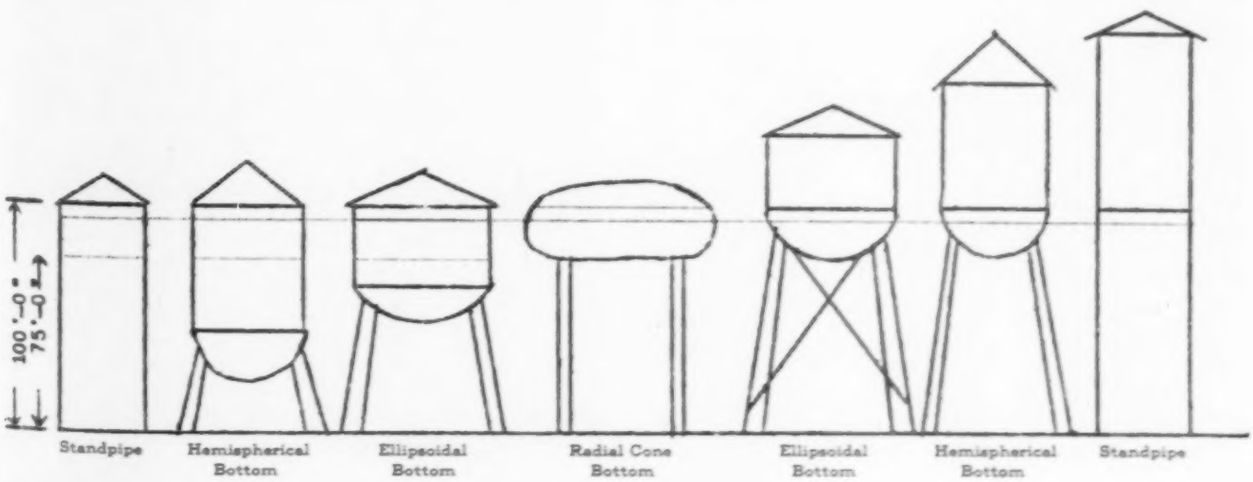
$X = 15000$ lb./sq. in. for structural columns.

$X = 15000$ lb./sq. in. for $\frac{t}{R} \leqslant 0.015$ or $D \leqslant 133t$ for tubular columns

$$X = \left[1{,}000{,}000\,\frac{t}{R}\right]\left[2 - {}^{2}/_{3}\left(100\,\frac{t}{R}\right)\right] \text{ for } \frac{t}{R} \leqslant 0.015$$

or $D \leqslant 133t$ for tubular columns

In these formulas, "l" is unsupported length, "r" the radius of gyration, "t" the plate thickness, never less than $\frac{1}{4}$ inch, and "R" the inside radius—all in inches.



* Presented at Armour Institute sponsored by the Chicago Section, A. W. S., and Hollup Corporation.

† Research Engineer, Chicago Bridge and Iron Co., and President, AMERICAN WELDING SOCIETY.

TANK PLATES

Tension, lb./sq. in., in bottom plates = $12000E = SE$
Tension in riser and all other tank plates = $15000E = SE$

"E" is the joint efficiency, and "S" is the basic design stress. For double butt-welded joints, and for single butt-welded joints with backing bars to which the weld metal is thoroughly fused, $E = 0.90$.

For full fillet lap-welded joints, which are limited to a maximum plate thickness of $^3/_8$ inch, $E = 0.4 + 0.4k$, where "k" is the fractional or decimal part of the seam which is intermittently welded on one edge, and continuously welded on the other; "k" is never to be less than 0.25. (If purchaser so desires, a $^3/_{16}$ inch continuous fillet weld may be used instead of a 25% intermittent full fillet weld.)

STRUCTURAL ATTACHMENTS

Shear on section through weld throat = 11300 lb./sq. in.
Tension on section through weld throat = 13600 lb./sq. in.

Stress in a fillet weld shall be considered as shear, for any direction of the applied load. In designing, due provision must be made for eccentricity in joints.

NOTE: It should be understood that the above values are reasonable ones, but not in agreement with all specifications.

Next, with the required capacity, range of head, and height of bottom known, the general dimensions of the tank and tower are worked out and the wind and snow loads figured. The wind stresses in the tower members are computed, assuming that the entire structure works as a vertical cantilever. The direct metal, water and snow loads on the columns and central riser are calculated by the usual principles of mechanics, as are the shears and moments in the radial girders. The application of these principles to these particular cases is not as simple as it sounds. Tank conical and cylindrical shell plate thicknesses are computed by the simple formula $t = \frac{PR}{SE}$ in which "P" is the maximum liquid pressure against the plate, in lb./sq. in., "R" is the conical or cylindrical radius in inches, "S" is the basic allowable stress in lb./sq. in., "E" is the joint efficiency, and "t" is the required plate thickness. The central riser is designed to resist the internal pressure stresses in tension and also to carry the vertical reactions from the radial girders as a column.

The stresses around the top of the central riser, and near the junction of the radial troughs and the cylindrical tank shell are somewhat indeterminate, and the design of these portions, therefore, partly a matter of judgment.

In general erection procedure, the field connections of the tower are riveted, and the shop details welded. The ends of the posts are quite simple, consisting of a base plate welded directly to each lower end, and a cap plate to each upper end. Anchor bolts into the foundation go through the base plate; fitting-up bolts attach the cap plates to the bottom flanges of the radial girders during field assembly, but the permanent strength connection is made by welding. The pin plates on the ends of the tower rods are manually arc welded, and the short rod ends are welded to the main rods by resistance welding. The lower wing plates for the rods are welded to the posts, the upper wing plates to the girders and the intermediate wing plates to the struts which, in turn, are riveted to the columns.

The central riser is usually built up in the field, ring upon ring, and butt welded. Erection is commonly started by setting the tub, consisting of the base plate and first ring of the riser, in place on the center pier, then assembling on it the erection derrick, which, from this position is used to erect all or part of the posts. Then the boom is lashed to the mast and the successive riser rings are put into position around the derrick and welded. When the riser is completed, an "A" frame is mounted on top of it, dead men for the derrick guys are planted and with the help of the frame and guys, the derrick is hoisted to the top of the riser, from where it lifts into place the remaining tower members, the radial girders, the tank plates and the roof trusses. After completion of the erection, the derrick is lowered to the ground through a hole in the bottom where one plate is left out for this specific use. During the lowering, the derrick is supported on the roof and roof trusses.

If tubular columns are used, the foregoing erection procedure is modified by building up the riser and hoisting the derrick to the top of it *before* any columns are raised. In this case both the riser and the derrick must be guyed.

The radial trough plates are usually butt welded—sometimes from the top only against backing bars and sometimes from both sides. The radial girders are of very simple construction, each being made of an unstiffened web plate, a bottom flange plate and a top flange bar to which two adjacent trough plates are welded by the same weld which joins the plates to each other. The girder flanges are fillet welded to the web. The inner ends of the girders are fillet welded to the riser.

The side sheets are usually double butt welded. As a rule, the roof is domed, and part of the dome space used for water storage. The dome plates below the high water line are double butt welded or single butt welded against backing bars on the inside; the dome plates above high water are lap welded on the top edges only.

The use of butt-welded tubular columns is increasing, because they not only lend themselves to artistic design, but also have structural advantages due to their great lateral stiffness. They are always double butt welded, usually by a combination of automatic and manual welding; are, as a general rule, completely fabricated in the shop, and are hermetically sealed.

QUALIFICATION TESTS

The value of qualification tests for welding operators is generally recognized. The AMERICAN WELDING SOCIETY has prepared a set of qualification rules which should be generally adopted as standard. "Standard Qualification Procedure, Section I, Manual Arc & Gas Welding, January 1938" can be obtained from the Society, 33 W. 39th St., New York, N. Y., at 25¢ per copy. Every welder should procure a copy.

The basic ideas back of these rules are:

(*a*) That each manufacturer prepare and record a PROCESS SPECIFICATION describing the materials, equipment and method by which he proposes to do his welding.

(*b*) That he then prove by a very comprehensive series of strength, ductility and soundness tests, called the PROCESS QUALIFICATION, that his welding procedure will produce good welds. These tests need never by repeated if he does not change his process.

(*c*) Finally, that he prove by relatively simple test of *soundness* only, called the OPERATOR QUALIFICATION, that his operators can make good welds, using the qualified welding process. The governing principle here is that there is no need for making strength and ductility test of operator's welds since the PROCESS QUALIFICATION has proved that *sound* welds are sufficiently strong and ductile.

ARC WELDING IN AIRCRAFT*

By RALPH H. UPSON†

IT IS not so much the function of this paper to describe the economies of arc-welded construction over riveted construction, which every one knows, as it is to set forth a type of design, embodying arc welding, that is usable in aircraft of the all-metal or stressed-skin type.

The specific features here proposed are all tried and proved, but the combination has not as yet been used. The Navy's metal-clad airship, ZMC-2, now completing its ninth year of successful service, embodies many of the physical principles involved, but owing to the lack of suitable high-tensile steels when it was designed and built, and the then general inadequacy of welding technique and equipment, it was necessarily made of riveted dural construction.

A recent self-propelled rail car, built by Stout Engineering Laboratories, embodies a welded steel tubular frame with a stressed dural skin attached to it by means of hardened, self-tapping screws, here advocated for aircraft because of the particular difficulty of driving rivets in this type of structure.

Since this rail car, a similar type of construction has been used in various automotive units with signal success, notably in light weight motor coaches (adopted by Gar Wood Industries) for over two years. The operation of these busses, under conditions of vibration substantially worse than anything in aircraft, has shown consistently excellent results. Unlike ordinary wheeled passenger vehicles, however, the surface skin of aircraft is subjected to the action of substantial pressure forces which must be taken into account.

* The author of this paper received the third main award, $1322.82, in Aircraft classification of the $200,000 Program sponsored by the James F. Lincoln Arc Welding Foundation, Cleveland, Ohio. (Abstract)

† Consulting Engineer, Kay Products Co., Detroit, Michigan.

Fig. 1—Wing Section Showing Present All-Metal Airplane Construction of Riveted 24ST Alclad

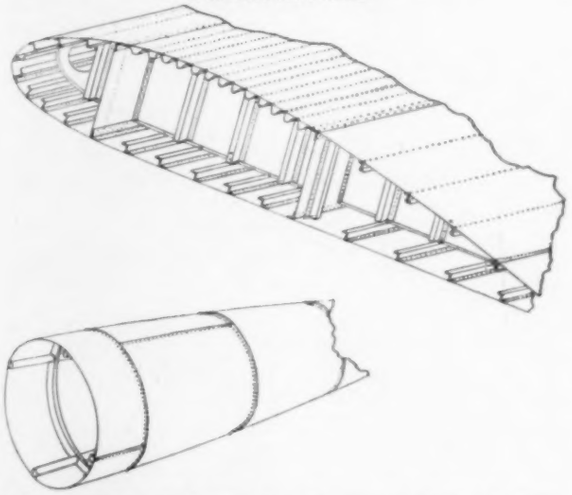
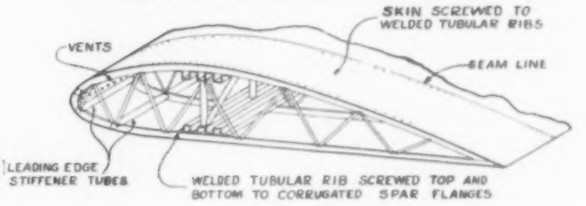


Fig. 2—Proposed Arc-Welded Fuselage Construction Air Intake Forward

Fig. 3—Arc-Welded Stainless Steel Wing


SKIN SCREWED TO WELDED TUBULAR RIBS
VENTS
BEAM LINE
LEADING EDGE STIFFENER TUBES
WELDED TUBULAR RIB SCREWED TOP AND BOTTOM TO CORRUGATED SPAR FLANGES
ALL FRAME JOINTS GUSSETTED

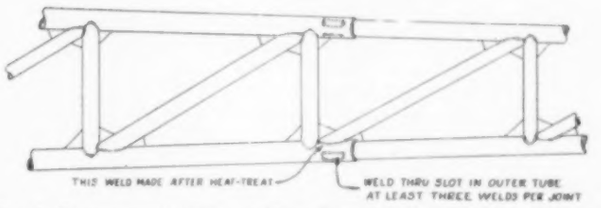


Fig. 4—Diagrammatic View of Wing Spar Showing Method of Using Heat-Treated Subassemblies

PRESSURE FORCES

Stressed-skin construction is in general so common that no detailed description of it will be necessary here; but the method of stiffening the surface to withstand the above-mentioned pressure forces is vital to the present discussion. This surface stiffening is usually done in one or both of two ways (Fig. 1). Either many closely spaced, separate, flanged stiffeners are riveted inside the skin bottom of (Fig. 1), or, as is becoming more common, the skin at least in part is built up of two layers, the outer layer being of smooth sheet running from 0.010 to 0.030 inch in thickness, while the inner layer is two to three times as thick and is corrugated (top of Fig. 1). This method has the stiffness characteristics of the old Ford Trimotor type construction in a direction that will do the most good, without the attendant increased surface friction. However, from the economic point of view, both current methods are sadly inefficient because of the large number of rivets required to make satisfactory fastenings between the outside skin and the inside stiffeners. Both methods also practically prohibit the general use of arc welding, because of the very thin walled elements involved.

The method herewith proposed for stiffening smooth aircraft skin has been used with outstanding success on the above-mentioned airship ZMC-2. By this method, panels as large as seven feet by sixteen feet of 0.010-inch 17 St Alclad were satisfactorily stiffened with no extra weight or added members of any kind. Fantastic as this may sound, it will be shown in this paper to be reasonable. And for those who are still unconvinced, the facts borne out by the ZMC-2 are indisputable.

The result is accomplished by maintaining and utilizing a pressure difference of small magnitude acting nor-

mal to the skin and always in the same direction. With this pressure difference, calculations and tests both show that there will be no tendency for the skin to flutter, and that the skin will be able to carry a proportional amount of shear or superimposed compressive stress without serious wrinkling. Theoretically and practically, in the case of the ZMC-2, the forward speed of the ship was found sufficient to maintain the required pressure difference at all times. The airplane, with its higher speed, will be still more definitely susceptible to this type of pressure control. In the event of local damage to the skin, the general redundancy of structure serves to carry stresses around the injured spot substantially as though there were no break. This has been verified by practical experience as well as by mathematical analysis and laboratory tests. A mathematical analysis of this type of stressed skin for airplane wings is given in the Appendix of the complete paper.

The external pressure distribution of the air around a wing in flight has been an object of study for some time, but the internal pressure has been left entirely to chance. As is well known, the maximum external pressure is confined to a narrow strip along the leading edge. This is easily reinforced by structural means. The outside pressure drops off so fast from this point that it is quite unnecessary to have as much pressure inside. Also the pressure is so much lower on top than on the bottom, that in some cases it is sufficient to have a pressure inside such that the pressure difference on the surfaces act outward on the top and inward on the bottom. Hence, controlling air vents are put at points where the pressure is just sufficient to insure the desired results. Scoops or leading edge vents (Fig. 3) of course give the maximum. The wing volume being small and the screwed seams relatively tight, only small intake openings are needed if properly located. Both inside and outside pressures are then automatically generated in proper proportion by the effect of the air-speed itself and the angle of attack of the wing. As can readily be seen, this very substantially simplifies the construction, besides concentrating the frame elements as required for arc welding. In the case of a fuselage, since the section is usually nearly symmetrical, the pressure would have to be great enough for the difference always to be acting outward. If the cabin is supercharged for high-altitude flight, the problem is already taken care of. If not, it is solved in the same way as for the wing (Figs. 2 and 3).

FRAME ELEMENTS

Considering the type of structural sections to be used, it must be admitted that its sufficiently thick members can be justified, particularly those which are well supported against buckling, tubing becomes less important and other considerations may prevail in the design of specific parts. The following examples show adaptations of both open and tubular sections. Skin attachment by screws, recommended in either case, is particularly desirable in the case of tubular supports, it being important however to use properly a type and size of screw suited to the purpose. Such screws have been shown to be particularly reliable when used in steel.

Two convenient methods, embodying the above principles, are shown for obtaining an arc-welded structure of high tensile steel. The first is the most straightforward, consisting merely of using initially heat treated or high tensile stainless stock in the fabrication, preferably the latter.

For purpose of illustration, the wing is chosen because it is considered to be the most important and critical part of an airplane. Here the wing beam is made up of two corrugated stainless steel flanges with lattice tubes of similar material, arc welded in place (Fig. 3). The flanges are tapered in width toward the tip. It should be noted that the corrugated flange is here used purely as a beam flange and does not support the skin. Hence, it can be made relatively narrow and of substantial thickness. In this type of construction, the rib members are preferably screwed to the beam flanges. The second method is to use unheat-treated stock to form subassemblies of such a size as to admit them to furnaces and quenching tanks readily available. These subassemblies are then heat treated after fabrication, and assembled by telescoping them together. They are secured in place by a series of "slot" welds (Fig. 4), designed to distribute the welding heat in axial lines and prevent loss of strength in the section as a whole. In this type of construction, of which the wing is again taken as an example, the rib members can be arc welded in place, by similarly restricting the lines of weld, with little loss of strength in the beam flange.

Naturally, arc welding is ideally suited to both of these constructions since the heat produced is highly localized. In either case, there is no need for diagonal bracing in the plane of the skin since the skin is an integral part of the structure and is designed to take the shear loads, developed as tension.

The skin may be fastened either to the spars or to the ribs with almost equal structural efficiency, but from aerodynamic and other considerations, it is deemed more satisfactory to use the rib fastening, which can be set on a spacing up to 8 times that of present stiffeners. In the case of a fuselage, it is usually more expedient to run the skin panels circumferentially with countersunk screw attachments to the transverse frames (Fig. 2).

In a wing designed by the author, the main beam is built up of heat-treated sections telescoped together as described above. The ribs are placed perpendicular to the leading edge instead of parallel to the chord so that the skin can be fitted on in straight, unbroken strips from under the trailing edge around the leading edge to the top of the trailing edge, without patterning.

COST ANALYSES

As an aircraft of this description has not yet been built, its cost must be estimated from knowledge and judgment based on the cost of materials, and experience with the various operations involved. The essential object will be to get a cost comparison between an arc-welded chrome-molybdenum steel tube frame with screwed-on skin, and conventional riveted dural construction.

On the above-mentioned rail car, the following figures applied as taken from observation of average workers on basic operations:

	Time in Minutes	Labor Costs	Mat'l Costs	Total
Plain "T" weld $1\frac{1}{2}$ inch O.D. tubes	10	$0.100	$0.075	$0.175
Continuous plate weld per inch	1	.010	.015	.025
Drilling and screwing per screw	1.5	.015	.005	.020

Applying this data to the construction of a pair of 20-ft. tubular wing spars and the skin attachments thereto, we find the cost analysis to be thus:

Cutting and fitting	$ 5.00
16 joints averaging 25¢ each (gussetted)	4.00
120 lattices @ 15¢ each	18.00
Misc. details	6.00
600 skin screws, inserted, @ 2¢ each	12.00
Total of above operations	$ 45.00
115 lb. of heat-treated chrome-molybdenum tubing @ 50¢ per lb.	57.50
Total of labor and material	$102.50

However, this does not give us the true picture because on this car, the screws were driven by hand, and the welding was done with gas. The reduction in direct welding costs is partially compensated for by a slight increase in the cost of tube fitting which must be done more carefully for arc welding than for gas if standard practice is to be accepted. As for power screwdriving, recent experience in two different plants indicates that it is at least three times as efficient as hand driving, reducing the labor cost of screwing from $0.015 to $0.005 per screw. Thus, correcting the above figures, we have as a liberal estimate:

Cutting and fitting	$ 7.00
16 joints @ 10¢ each	1.60
120 lattices @ 10¢ each	12.00
Misc. details	6.00
600 skin screws inserted @ 1¢ each	6.00
Total of above operations	$32.60
115 lb. of heat-treated chrome-molybdenum tubing @ 50¢ per lb.	57.50
Total labor and material	$90.10

Now let us investigate a comparable structure of riveted aluminum alloy (24ST). These figures are also based on time studies:

Flanges (layout, notching and reinforcing)	$ 54.00
Lattices (layout and assembly)	27.00
Misc. details	14.00
Spar assembly	48.00
600 skin rivets inserted @ 3¢ each†	18.00
Total of above operations	$161.00
125 lb. of 24ST sheet and rolled sections @ 50¢ per lb.	62.50
Total labor and material	$223.50

This is 150% more than the arc-welded steel construction to say nothing of its being ten pounds heavier, the strength being the same.

It should be noted that the above comparison is between wing beams of closely similar type except for the material and method of assembly. If the proposed welded steel construction (Figs. 3 and 4) with concentrated frame elements is compared to the type of construction at present actually used for all-metal aircraft, the latter appears still less favorable because of the supplementary riveting required for the attachment of skin stiffeners or alternative corrugated layer (Fig. 1). In other words, the improved construction is not only cheaper per joint, but there are far fewer joints in the structure as a whole.*

It is extremely doubtful if the above costs include enough allowance for delays caused by mistakes in cutting and fitting the many different gussets, drilling out and replacing bad rivets, etc. Bending the 24ST sections is a much more serious problem than bending steel tubes; and a modern airplane must necessarily include a large proportion of curved members. The mounting of the various small fittings may take anywhere from twice to four times as long when riveted as compared to welding (or screwing to a welded steel frame).

When making up 50 to 100 complete units at once, the direct labor on the welded construction would remain substantially the same, while the labor per unit on the riveted construction can be lowered considerably. In the industry, opinion differs as to the amount of this reduction, but even the most drastic estimate reduces it by only one-half, which leaves the riveted construction still costing almost 60% more than the welded steel tube type neglecting entirely any reduction in the latter.

The extra drafting time required to design an airplane of riveted construction must necessarily be something of a guess, but informed opinion again leads to the belief that it would be at least 50% more than for a comparable arc-welded steel job. This in itself would not be so serious if it could be amortized over a large number of identical units, but any change or new fitting desired will always involve work in the drafting room as well as in the shop and it is here that the drafting time becomes most important.

PERCENTAGE COST COMPARISONS

Inasmuch as aircraft construction companies seldom, if ever, can prepare in advance an accurate estimate for the finished product, it is obviously beyond the scope of this paper to present detailed cost analyses of an entire ship. Therefore, in preparing cost comparisons for completed units, the author will draw upon his experience gained during the 28 years he has been identified with the industry. On this basis, the following percentage savings from present costs for the various sizes and types of completed units seem well on the conservative side:

For a large rigid airship	20% saving
For any present all-metal air transport	30% saving
For an airplane such as the Waco Cabin or Stinson Reliant	0%
For a light plane such as the Cub or Aeronca	10% increased cost

CASH COST COMPARISONS

In terms of dollars and cents, these figures take on the following aspect.

Since the late airship Hindenburg cost in the neighborhood of $4,000,000 the same size could be built in this improved way at a saving of $800,000 approximately. An airplane the same size as the Douglas DC-4 could be built for $350,000 as compared with the reported present production cost of $500,000; a net saving of $150,000. An airplane of size comparable to the Waco or Stinson would cost substantially the same as the present ship, while a small light plane would cost somewhat in excess of $100 over current costs, due to the restricted applicability of arc welding for the light framing involved. However, in these last two examples, one must not lose sight of the fact that although there is no present cost saving, the highly inflammable, easily damaged fabric covered structures will have been replaced by stronger and comparatively permanent all-metal structures of substantially the same weight, a result which, if attained by prevailing methods, would cost 50 to 70% more than the present ship. In the case of the conventional rigid airship, the generally perishable and inflammable construction is replaced by one that is not only much stronger and more determinate, but is

* The total number of rivets (reported to be 1,300,000 in the new Douglas DC-4) would be replaced by not over one-fourth as many screws.

† The inserted cost of skin rivets on present all-metal airplanes averages from 3¢ to nearly 10¢ each.

also fire-proof. Recent airship disasters would indicate that this is the *only* comprehensive solution to the airship problem.

These cost estimates are for the entire aircraft, although the actual saving considered is for the main structure. If arc welding can similarly be utilized in important operations on the power plant and other accessories, the total saving will be, of course, still greater.

Other Advantages

Low first cost is not the only attractive thing about this type of construction, even in comparison with present all-metal airplanes. Other points to consider are:

1. Incidental improvement of structural arrangement can be effected through not having to provide internal access to rivets.
2. The general segregation of structure allows plenty of room for wheel wells, fuel tanks and baggage space.
3. Concentrated loads from landing gear, engine nacelles, etc., are readily handled; and the substantial character of individual members makes them generally able to take "punishment."
4. Subject to effective corrosion prevention, steel is known to have a higher fatigue limit than the "light" alloys.
5. Inspection and repair are greatly facilitated by the reduced number of frame elements, and the screwed-on skin.
6. An appreciable saving in weight is possible and will probably be realized with further development.
7. Great rapidity and widespread facilities of production offer a tremendous advantage in case of war.

Of the few possible disadvantages, assuming adequate material thickness here provided for, the matter of shop inspection should be mentioned. The difficulty as to inspection of arc welds in aircraft is not thought to be more than can be worked out by establishing suitably high standards, checked by a reasonable number of tests, and rigidly enforced. The need for such standards must be recognized, however.

POSSIBILITIES FOR THE FUTURE

In the light of research and development now in progress in new and better materials and equipment, it seems only reasonable to expect that cost can be reduced still further in the future, and applied to thinner walled structures, even to the extent that relatively small, fabric covered ships can be redesigned in metal at a substantial cost saving by making use of this improved construction. Most noteworthy of present developments is a new nickel-molybdenum steel that has better welding characteristics than the chrome-molybdenum alloy, together with more favorable physical properties. Another asset of this new steel is that all of its constituents are obtainable in this country and Canada.

Riveting, over the course of several generations, has been very highly developed. In fact, one is tempted to wonder whether its refinement has not reached a limit. Arc welding, on the other hand, is still in its infancy, and no limit to its possible attainments is yet in sight.

On the basis of arc-welding equipment and technique at present available, the smaller aircraft will require the larger proportion of non-arc welded joints; but the principles of design and construction here shown will in any case permit a maximum utilization of the arc-welding process. Although this paper is concerned with designing the product to suit arc-welding conditions, rather than with the production equipment, it is worth noting that further refinement of such equipment and methods of use will be most valuable in the direction of permitting general assemblies to be formed from thinner stock. Using the structural features here proposed, ability to reliably arc weld steel down to about 0.016 inch thickness (28 ga.) with full strength, should take care of the major part of any airplane, except skin attachment, regardless of size.

In spite of the high first cost of present all-metal air transports, they have been found far more durable and more economical in operation than fabric covered ships. For private operation, however, the first cost has been an almost complete barrier to the use of all-metal construction. What is needed is a method by which all-metal private aircraft can be produced, in relatively small quantities at first, but at a price to compete directly with fabric. Even though it may involve no initial cost saving, this should be an important factor in promoting the increased sale and production on which production cost itself so largely depends.

Hence, the approximate two million dollars a year that can be *saved* in the air transport industry, as at present constituted, may be of small importance, compared to the increase of *business* that may be stimulated, especially in a field that has hitherto been relatively neglected but is potentially the biggest of all, the private market. Arc welding, with suitable structural design, is a key to this situation.

The proposed construction, increasingly feasible for larger craft, will here provide a welcome simplicity in comparison to the ever increasing structural complication of large aircraft to date.

CONCLUSION

Subject to design criteria developed in the Appendix of this paper, the arc-welded, concentrated steel construction, with screwed-on skin under the proper normal pressure, has qualities that should make it more economical and generally more satisfactory than prevailing forms of aircraft in sizes larger than the very smallest airplanes; and it is expected that future developments will render even the latter class of aircraft susceptible to cheaper as well as better construction by this method. The author counsels against undue haste, however. In this, as in any new design, progressive refinements from practical experience, together with inherent economies and other advantages, can be fully realized only through slow, orderly development.

AUTOMATIC CARBON ARC WELDING in the Automotive Industry*

By F. M. MAICHLE†

AUTOMATIC shielded carbon arc welding has become the accepted method for fabricating various automotive parts. In this industry where production is sufficient in amount and of relatively uniform character, this process provides very low fabricating costs and the weld so produced is in all cases equal to or better than the requirements of the design.

The high quality and low cost of welding by the shielded carbon arc process, are the result of the development of the electronic tornado system of controlling the carbon arc in automatic welding.

Focusing and localizing the arc stream so that all the heat is concentrated in a very small area directly beneath the arc, is of tremendous importance. This controlling of the arc, so that all the heat is concentrated, is accomplished by superimposing a strong magnetic field on the arc stream. This magnetic field checks wandering tendencies of the arc and gives the electrons of the arc stream, a rapidly gyrating motion which puddles the molten metal and refines it. It is this swirling motion of the electrons which gives the electronic tornado its name.

It is evident that the weld metal produced under the conditions so far described, would be subject to the action of the atmosphere and would, therefore, be irregular in quality since contact of the molten weld metal with the atmosphere would produce oxides and nitrides in the weld.

To offset or eliminate this possibility, a controlled atmosphere or shield is formed around the arc in the electronic tornado system of automatic welding.

Since there is no metal passing across the arc, the oxygen and nitrogen of the air have less opportunity to combine with the molten weld metal. The only point, therefore, which must be protected, is that at which fusion takes place. This protection is provided in the electronic tornado process by the introduction of an autogenizing element into the arc flame at the point of fusion.

This autogenizing element burns as it comes into contact with the hot carbon. As this material burns, it liberates gasses which shield the arc and provide an atmosphere void of oxygen and nitrogen around the weld metal. This protection is maintained until the weld metal is cooled since a protective layer of slag is formed over the weld.

This process of shielding the carbon arc, has led to the use of the phrase—"shielded carbon arc process" when referring to the electronic tornado system of automatic carbon arc welding.

DESCRIPTION AND OPERATION

The automatic electronic tornado welding head (see Fig. 1), is a mechanism for holding a carbon welding electrode, automatically striking the arc, automatically feeding the electrode, so as to maintain a constant arc length at all times, and rotating the electrode so as to keep the electrode symmetrically pointed. An electromagnetic feature is used to control the arc flow and provide electro-magnetic forces for agitating or working the weld metal while it is molten. The continuous working of the molten weld metal facilitates the exodus of non-metallic inclusions and gasses from the weld metal.

The welding head consists of a cast aluminum case, containing a feeder body, for striking the arc and rotating and feeding a carbon electrode. This feeder is driven by an electric motor mounted integral with the head. The electronic tornado boot or nozzle, is attached to the head.

This boot consists of a water cooled body for conducting the welding current to the carbon electrode and a coil with magnetic core for producing the desired magnetic field around the arc. Two types of tornado boots are furnished as required: a direct current tornado and an alternating current tornado. However, in either case, the direct current arc is used for welding. The direct current tornado is energized by a coil in series with the arc. When an alternating current tornado is

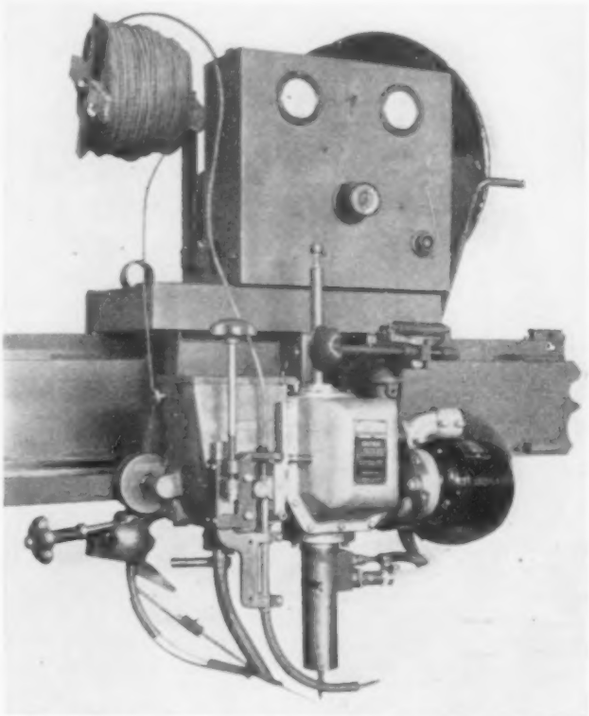
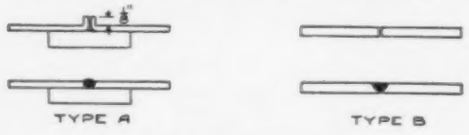


Fig. 1—"Electronic Tornado" Automatic Carbon Arc Welder

* Paper presented at annual meeting of the AMERICAN WELDING SOCIETY at Detroit, Mich., October 16–21, 1938.

† The Lincoln Electric Company, Cleveland, Ohio.

SPEEDS & COSTS OF AUTOMATIC ARC WELDING
BY THE ELECTRONIC TORNADO PROCESS



BUTT WELDS TYPE A

THICKNESS OF METAL	20Ga.	18Ga.	16Ga.	14Ga.					
WELDING SPEED, FEET PER HOUR	140	140	135	125					
COST PER LINEAR FOOT OF WELD	.009	.009	.010	.011					

BUTT WELDS TYPE B

THICKNESS OF METAL				14Ga.	12Ga.	10Ga.	3/16"	1/4"	5/16"	3/8"
WELDING SPEED, FEET PER HOUR				300	260	190	180	120	100	75
COST PER LINEAR FOOT OF WELD				.005	.006	.008	.013	.016	.019	.024

SPEEDS & COSTS OF AUTOMATIC ARC WELDING
BY THE ELECTRONIC TORNADO PROCESS

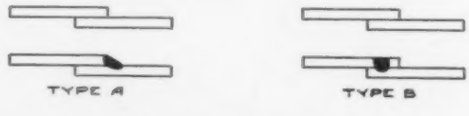
EDGE WELDS TYPE A

THICKNESS OF METAL	20Ga.	18Ga.	16Ga.	14Ga.	12Ga.	10Ga.	3/16"	1/4"
WELDING SPEED, FEET PER HOUR	250	225	200	185	170	150	140	135
COST PER LINEAR FOOT OF WELD	.005	.006	.007	.007	.008	.010	.012	.012

CORNER WELDS TYPE B

THICKNESS OF METAL		18Ga.	16Ga.	14Ga.	12Ga.	10Ga.	3/16"	
WELDING SPEED FEET PER HOUR		130	130	130	115	110	90	
COST PER LINEAR FOOT OF WELD		.009	.009	.009	.012	.017	.018	

SPEEDS & COSTS OF AUTOMATIC ARC WELDING
BY THE ELECTRONIC TORNADO PROCESS



LAP WELD TYPE A

THICKNESS OF METAL	18Ga.	16Ga.	14Ga.	12Ga.	10Ga.	3/16"	1/4"	5/16"	3/8"
WELDING SPEED FEET PER HOUR	150	135	125	110	100	90	70	50	40
COST PER LINEAR FOOT OF WELD	.008	.010	.011	.016	.016	.018	.022	.031	.038

PLUG WELD TYPE B

THICKNESS OF METAL		16Ga.						
WELDING SPEED FEET PER HOUR		75						
COST PER LINEAR FOOT OF WELD		.011						

Figs. 2, 3 and 4

used, a 110 volt A.C. 50 or 60 cycle supply of about 3 ampere capacity is required.

Since the tornado boot is water cooled, it must be supplied with water at from 30 to 80 pounds per square inch pressure. The water rate need not be more than one gallon per minute. An automatic water switch is provided to prevent operation until the water has been turned on.

The feeder body assembly consists of a set of differential gearing provided with friction drums. If both drums ("A") are allowed to rotate freely, they will rotate at the same speed and the electrode holder will not be raised or lowered. If the upper drum is retarded, the electrode holder will be fed upward. If the lower drum is retarded, the electrode holder will be fed downward. Each drum is provided with a magnetically operated brake for controlling the operation of the electrode holder. These brakes are controlled by a differential relay mounted on the contactor panel.

Most of the control equipment is of a commonly used type and no description is necessary. However, the differential relay and time-delay switch are a special design and therefore will be described briefly.

The differential relay is mounted on the front of the contactor panel and consists of an armature suspended on flat springs so as to float them freely inside of a set of differential coils. The armature operates the set of contacts at the ends. The coils on the left hand are connected across the arc, the coils on the right hand are connected across the constant potential circuit, through an adjustable slide-wire rheostat mounted in the control box, directly above the automatic head and within easy reach of the operator. By means of this adjustable rheostat, the voltage across the right hand coils can be set to any desired value up to 50 volts. The voltage across these coils is known as the "reference voltage" and is indicated on the reference voltage voltmeter mounted on the control box, at the operator's station.

The two sets of coils are connected in opposition to each other so that when the arc voltage is exactly equal to the reference voltage, the armature remains in its central position and neither contact is closed. If the arc voltage exceeds the reference voltage the armature swings to the left, closing the contacts, energizing the down feeding brake coils in the head, which causes the arc to be shortened until the arc voltage is just equal to the reference voltage.

If the arc voltage is less than the reference voltage the relay swings to the right, energizing the up feeding brake coils, causing the arc to be lengthened until the arc voltage is equal to the reference voltage.

Thus, the differential relay keeps the arc voltage and consequently the arc length, at a constant value, which is determined by the setting of the reference voltage.

The sensitivity of the differential relay is increased by a "kick" coil, mounted inside the differential coils and connected in series with the contacts. The arrangement is such that in actual operation, the armature vibrates rapidly from side to side when functioning in a normal manner. Resistors are connected across the contacts to prevent destructive arcing at the contacts.

The time-delay switch is a mechanism for securing a sufficient time delay to allow for proper establishment of the arc and to insure the proper penetration at the start of the weld.

This time-delay switch is mounted on contractor panel and is operated by an arm of the relay extending through the panel. This switch is of the mercury type which depends upon the fact that when the switch is rotated from the horizontal to a vertical position, mercury runs through a small orifice into a reservoir and bridges successive contacts as the mercury level rises in the reservoir. Thus, the time delay is adjustable, depending upon which contact points are used.

APPLICATIONS

In some applications the welding head travels along an overhead travel arm, welding the seam while the work remains stationary under it. The set-up consists

Fig. 5—Forming Operations on Rear Axle Housing

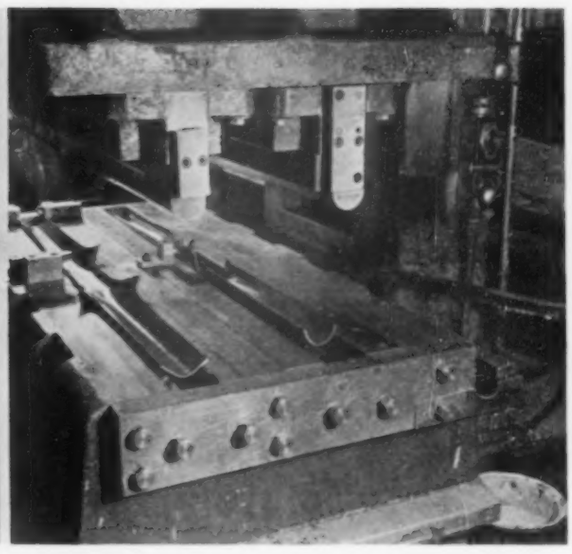


Fig. 6—Final Forming Operations of Rear Axle Housing

of a simple fixture for holding the work and a second power driven fixture for moving the welding head along the seam.

In other applications the welding head remains stationary while the work moves under the carbon arc. In this instance, the fixture holds the welding head at the proper distance from the work, while another fixture moves the work along under the arc.

Inasmuch as the equipment is not an integral part but is merely adapted to the various fixtures, as will be seen from a discussion of applications which follows, it merely remains to adapt it to any type of fixture built and designed to take the new part or piece, depending upon the change from year to year models.

The complete equipment, adaptable to any type fixture, consists of the automatic head, fibrous autogenizer or flux feeder, wire feeder (if needed) and a motor generator set.

Possibly one of the oldest applications is that of fabricating frames for automobile starters and generators. These frames are cylinders formed of $^{5}/_{16}$-inch and $^{3}/_{8}$-inch steel plate with edges butt welded. A total of $5^{1}/_{2}$ inches of welding is required on each frame. These are welded at the rate of 240 pieces per hour.

These torque tubes are mounted in boxes provided with mandrels. These boxes serve as jigs to hold the tubes while they are propelled beneath the head which, in this case, is stationary. The process is continuous, the boxes being loaded at one end, the tubes welded, then the boxes unloaded at the other end of the travel, and returned to the starting point, where they are again loaded and the operation continues without interruption.

The torque tubes welded in this instance vary between 48 and 66 inches in length. The thickness of metal is $^{5}/_{32}$ inch. After the welding is completed, the tubes are upset. No excess metal is required to provide for swaging. A tremendous savings in material cost is effected. The exact amount dependent upon the analysis of the steel and the type of tube. Where required, tubular parts are upset at the end after welding. These tubes have been upset from $^{3}/_{32}$ inch to $^{3}/_{8}$ inch, the equivalent of thickening the walls four times without splitting the weld.

Many other tubular shapes, both large and small in size may be fabricated by this method.

Mufflers for one of America's most popular-priced automobiles are arc welded by the electronic tornado process at the rate of 250 completed units per hour. Seven electronic tornado units are used. The welding of these mufflers consist of two operations. The heads are welded to the inlet and outlet tubes by four electronic tornado units at the rate of a completed muffler every $8^{1}/_{2}$ seconds. The heads are 18-gage thickness and $6^{1}/_{4}$ inches in diameter—a total of 12 inches.

The other step is the welding of three louvered tubes to the inner shell. The tubes are 18 gage material, $1^{1}/_{2}$ inches in diameter and 18 inches in length—a total of $19^{1}/_{2}$ inches of welding is required.

FACTORS TO BE CONSIDERED

From the foregoing it is seen that high quality welds for all automotive parts are not only desirable, but necessary. I would like to digress long enough to consider how the shielded carbon arc of the electronic tornado produces high quality welds. The quality of the weld will depend largely on four items:

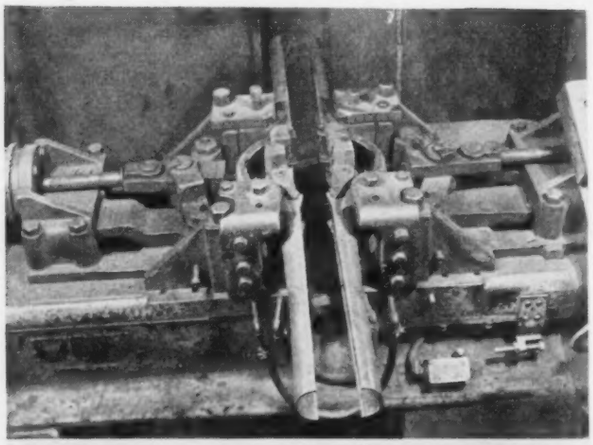
1. The type of steel
2. The thickness of the plate
3. The type of joint
4. The flux used.

Let us first consider steel. At some time during manufacture, all steels are high in oxygen, but before casting into ingots, some steels are deoxidized or killed which is a chemical means of removing oxygen. Some of the common elements which remove oxygen from steel are carbon, manganese and aluminum. Therefore, the total oxygen in the finished weld will depend upon carbon and the other deoxidizers added and the flux or autogenizer used in the welding process.

On plate thicknesses of $^{3}/_{16}$ inch or more, fibrous flux is used because the molten puddle or crater is large and it is necessary to use the flux to protect the metal from the air. A painted type flux, if necessary, is brushed on the joint to correct the chemistry of the steel.

Steels high in phosphorus (0.05 or more) are poor welding quality generally. Steels high in sulphur (0.05

Fig. 7—Two Halves of Housing



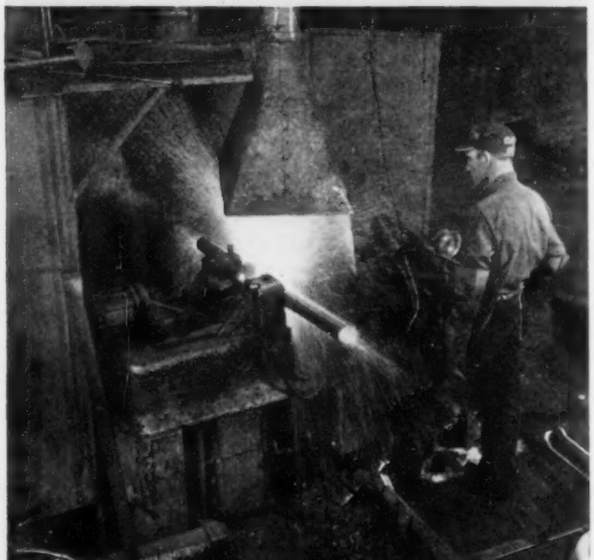


Fig. 8—Flash Welding Two Halves of Housing Together

or more) can be welded successfully if the manganese is six to eight times the sulphur.

In a major part, therefore, it is seen that the high quality weld is due to controlled atmospheric conditions and to other inherent, though basically simple, principles which are characteristic of the electronic tornado process. During the welding, the process also has a heat-treating effect which partly accounts for the remarkable uniform structure of the weld. In all cases, welds produced by this process are comparable in physical properties to the parent metal of the piece welded.

PROCEDURES, SPEEDS AND COSTS—TYPES OF JOINTS

The speed of welding by the electronic tornado is very high due to the amazing way this process focuses the heat of the electric arc in a very small area, directly upon the edges of the plate on either side of the seam being welded. Naturally a maximum of speed and more economical welding are obtained when the welding procedure is correct and when the quality of the base metal is the best suited for the particular application. Consideration of the various types of weld will indicate that the welding speeds shown in Figs. 2, 3 and 4 are far greater than those available with any fusion welding process. The accompanying diagrams illustrate the various types of welds made at high speed and great economy by the electronic tornado process.

A type of butt weld is illustrated in Fig. 2*A* as shown in the diagram, the edges of the plate are turned up making use of additional filler metal unnecessary. The work may or may not be clamped in position on a copper backing strip but the welds made are with 100% penetration.

Type of butt weld used in the automatic welding of rear axle housings, generator frames and many other products, is illustrated in Fig. 2*B*. The seams are clamped tightly together without backing and no filler metal is added.

Fig. 3*A* type of edge weld used in the manufacture of mufflers, requires no additional filler metal, the parts to be welded being simply fused together by the shielded carbon arc.

Fig. 3*B* illustrates corner welds used in the manufacture of rectangular tubing for frames and housings.

Fig. 4*A* shows lap welds used in the manufacture of various automotive parts such as hubs, disk wheels, etc. The work is clamped into position without the use of backing and 100% welds are made.

Fig. 4*B* shows weld through the lapped plate with sufficient penetration to obtain 100% strength. This application is typical of welding inserted tubes as in remote control gear shift assemblies.

WELDED REAR AXLE HOUSINGS

In order to convey the part that this equipment plays in an actual fabrication process, let us now take up, step by step, the fabrication of a rear axle housing for one of America's most popular cars.

Forming operations are performed in a hydraulic press using a 5-station die. In this press the flat blank is formed in five operations into the trough shape shown in the part of the die at the right of the picture. Each piece is shown as it is formed in the station which it occupies. As there are always five pieces in the press, a piece is turned out every fifteen seconds (see Fig. 5).

Final forming and re-strike operations are performed in a hydraulic press using 2-station die. In the first station of this die, the half-banjo is formed. In the re-strike operation or station the edges of the half-tube are coined out, $^{15}/_{1000}$ths, to furnish additional thickness for the weld. One piece is turned out every twenty-four seconds or per press stroke. The next operation, although not shown, is that of the washer (see Fig. 6).

Next, the two halves (see Fig. 7) are flashed together at the banjo. This tacks the two halves together preparatory to automatically welding the long seams with the electronic tornado carbon arc process. This shows the flash welder in operation, tacking the two halves of the banjo housing together. This operation takes forty-one seconds (see Fig. 8).

Figure 9 shows the banjo housing and jig of the electric tornado carbon arc automatic seam welder ready for welding. The two electronic tornado boots are seen at the top of the picture with the carbons projecting from

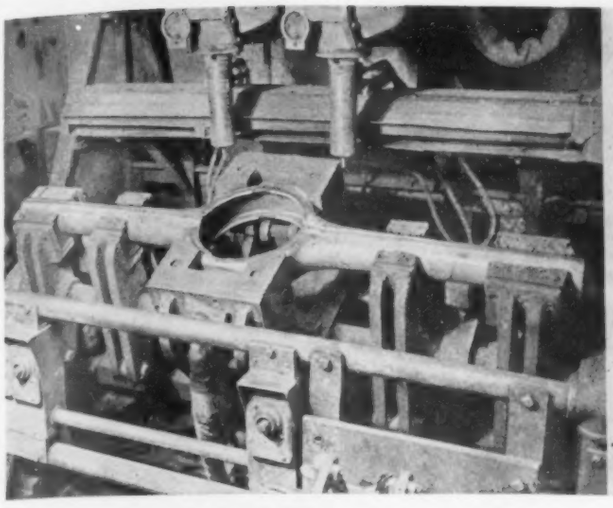


Fig. 9—Rear Axle Housing in Jig Ready for Automatic Carbon Arc Welding

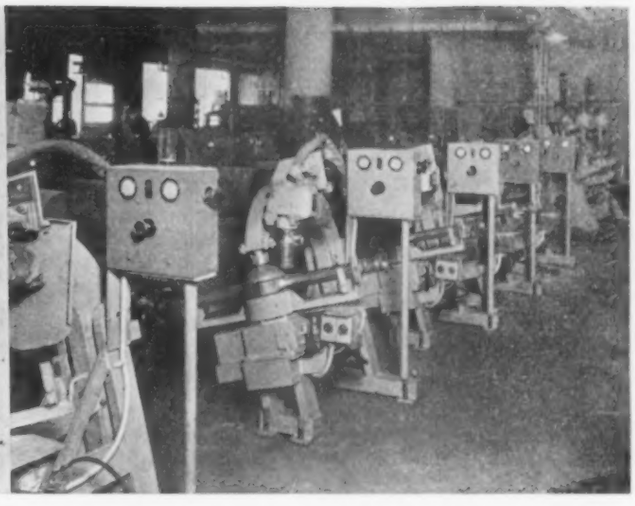


Fig. 10—The Final Step in Production of Rear Axle Housing—Welding the Covers in Place

the lower end. In the welding operations, the two carbons automatically strike arcs at the center of the housing. After a short interval, to allow the arcs to bring the metal to molten, the heads move out from the center, playing the arcs on the seam and puddling the edges together. . . . Upon arriving at the end of the seam, the arcs are automatically extinguished and the heads returned to the center. This operation is performed on each side of the housing. The time for this operation—that is both sides of the housing—is forty-three seconds. One man does fifty-three per hour on two machines, at an operating factor of about 63½%.

This shows the final job—the welding of the hats or covers on the differential housing of the rear axle (see Fig. 10).

There are several other applications which are now being handled on a production or experimental basis worthy of mention. These are the welding of propeller shafts, both the tubing and the lap-weld; a very high-speed method of fabricating exhaust tubing; using an oscillating electronic tornado and employing *hot-rolled* rather than *cold-rolled* stock; Diesel engine cylinder walls; front axles of tubular section and stampings for a special light weight though rigid construction; "A" frames for independent front wheel suspension of pressed steel and welded construction; edge and butt-welding on compressor housing assemblies for air conditioning of cars. Constant oil level reservoirs for busses, trucks, etc.

Whatever the application, the cost is based alone on labor, current, and carbon and the flux used as the fabricator is the owner of the equipment.

The electronic tornado system of automatic welding is especially adaptable to automotive work because decentralization of equipment and work is possible due to the simplicity and low cost.

There is less power consumption because power is furnished by a motor generator set with small installed horsepower. Inexpensive supplies are expended in the operation inasmuch as all that is involved is carbon and flux. The operation is completely automatic because all that is necessary is for the operator to push the starting and stopping button as the arc makes and breaks automatically and the fixture is automatic as well. Duplication of satisfactory welding conditions are easily obtainable. It is possible to keep a sufficient parts bank always on hand because of the high speed of production.

The growth of the application of welding in automobile manufacture has been increasing more than 100% every year since 1934. The reason is simple. Welding is stronger, lighter and infinitely cheaper. The importance of welding is indicated by the fact that engineers estimate the cost of producing a popular-low-priced car without welding today, would total $3000.

The Relation of the Engineer to the Welder and the Foundryman*

By T. B. JEFFERSON, M.E.†

THE welder and the foundryman probably never think of their relationship to the engineer. Most of the members of these crafts would quickly disclaim any connection to the engineer if they believed a relationship existed. Many welders either fail to realize or are unwilling to admit that they owe to the engineer the very fact that they are able to work at the welding trade. However, without the engineering research which has been undertaken in the field of welding, many of the welding methods and processes of today would be non-existent. To the founder, the engineer should be thought of as one who has made foundry work easier and more desirable through the introduction of machines and improved methods in foundry practice.

The engineer and engineering practices have rightfully assumed a place of prominence in every operation involving the use of metals. Particularly those operations related to the producing, shaping and fabricating of metal structures. In this paper, however, the engineer is to be considered only as a designer confronted with the fabricating problems commonly encountered in the production of articles or iron and steel.

* Presented before Montana Section, AMERICAN WELDING SOCIETY.
† Engineer-in-charge U. S. Engineer Shops, Fort Peck, Montana.

In the designing of most of the items to be made from these materials, the engineer has a choice of four fabricating processes, namely; casting, forging, stamping and welding. For efficient and effective designing he must be well acquainted with each of these fabricating processes and be able to select the proper method for the job at hand.

Forging is the most desirable of all of the methods of manufacture for the production of steel parts. The forging process is essentially an operation in which hot semiplastic steel is forced under pressure into the desired shape. This may be accomplished either by pressure applied through rolls or presses, or by a series of blows delivered by a power or hand hammer. The use of forging makes it possible to do all of the shaping of the metal while it is heated well above its critical temperature. In this manner, all of the possibilities of inducing fiber stress into the structure during manufacture are eliminated.

While forging is the most desirable, it is also the most expensive method of manufacture. Each item of different design, when produced by forging, requires a special set of dies. Likewise, highly skilled labor is required for the carrying out of the forging operations.

Competition, however, is continually forcing the manufacturer to seek less expensive production methods. The forged steel part, because of its high labor and tool costs, is being supplanted rapidly by parts produced by one of the other fabricating processes.

Stamping or pressing is essentially a cold forging operation. In this manufacturing process, the various items to be produced are formed by the use of large presses fitted with dies. The production cost of stamping, as in the case of forging, is very high because of the high labor and tool charges.

Extensive use of pressing or stamping is limited by the fact that only relatively thin metal sections can be formed by this method. Another disadvantage of this type of manufacture is that cold work tends to produce "locked-up" stresses in the finished metal structure. Under severe service conditions such stresses frequently result in failure of those parts affected.

In an attempt to offset the excessive production cost of the aforementioned fabricating methods, the engineer turned to the foundry and weldery. By working with and studying the problems of the founder and welder, he obtained a thorough understanding of these industries. Aided by this knowledge the engineer set out to improve the designs, methods of manufacture and the manufacturing equipment of these processes.

Until recently most of the designs for welding were merely copies of designs intended for a cast or riveted structure. Other than a slight reduction in weight of the finished product, little was gained by these designs. Usually, however, the welded structure was excessively strong. This indicated that welding offered definite advantages and result in the engineer designing for welding rather than merely duplicating a previous design for a cast or riveted structure.

In designing parts of welded steel construction to replace casting, the engineer was able to point out to the founder the fundamentals required of the foundry. In this manner, the engineer assisted the founder in the analyzing of his foundry problems. In turn, the founder was able to suggest to the engineer many of the errors of age old customs in foundry practice. This exchange of ideas resulted in many changes in the foundry. These changes have not only improved the quality of the castings produced, but have also reduced their production cost. Probably the most outstanding improvement of the foundry was the replacement of iron castings with steel castings. This change removed from competition welding's leading challenge against the foundry—that of weight reduction.

This aggressiveness in the foundry definitely made a place for castings in the present day scheme of welded design.

During this transition in the foundry, many of those associated with the welding industry were fighting to eliminate entirely the use of cast products. To some of the more enthusiastic members of the welding industry, the foundry was soon to become "a thing of the past."

The engineer, however, through his knowledge of both the weldery and the foundry was able to bring about a peaceful settlement of the feud between these industries. He has been able to cite clearly the factors effecting these industries and the many equal advantages of the respective processes. Furthermore, he indicated how each could be of mutual assistance to the other.

There are many factors to be considered in the design of an article which ultimately decides whether it is to be a job for the founder, the welder or will combine the efforts of both of these crafts. These factors are primarily: delivery, quantity, direct labor cost, machining cost, stress concentration and reduction in weight.

Delivery is probably the most important of these factors, and closely related to delivery is the quantity desired. If the delivery time is short or there are only a few items required, welding is the logical means of fabrication. In these cases, welding usually will complete the job before a pattern could be made for casting such a part. Likewise, the added cost of a pattern would make production cost excessive for only a few items.

In the making of an intricate structure, however, it may be that a complex casting will be less costly than a welded part. It should be borne in mind that the cost of a welded piece is directly proportional to the number of pieces to be joined and the inches of welding involved.

Occasionally the design is such that welding and casting may be combined to make the most economical structure in the shortest time. A gear case is a typical example of this type of construction. In many gear cases the wall sections are so thin that foundry losses are high because of warpage and defective castings; yet to build by welding is impractical because of the large number of bosses, etc., required which result in high welding cost. A combination structure in which plates are used for the thin sections and to which bosses cast in groups are welded is a logical and economical solution to such a problem.

Labor cost, machining cost, stress concentration and weight reduction are no longer an advantage for either the weldery or foundry. Here again the engineer by his close association with the craftsmen has introduced short cuts, improved processes and heat treatment methods so that neither industry can show a marked advantage over the other.

These cooperative efforts on the part of the engineer, the welder and the foundryman has brought into existence a definite relationship between the three. The engineer, by using castings where numerous and expensive welding operations are required because of the complexity of the structure, or by welding at points where the economics of the case justify the use of welding, has been able to strike a happy medium by using a combination of casting and welding. Through these efforts, the welder and the foundryman have worked with the engineer in such a manner as to combine their processes so that the consumer may obtain the most satisfactory article for the existing condition.

THE TEACHING OF WELDING AND Heat Treating as Applied to Engineering

By O. M. HARRELSON*

THE processes of welding and heat treating have gained so much favor, due to their extensive use, that their engineering science has been greatly developed and has come to occupy a very important place in the program of training engineers. It is a very important phase of training because there is no process in all industry that involves so many factors or variables as those encountered in fabrication by welding, and in heat treating. A thorough understanding of the processes requires knowledge of many branches of science.

Many articles have been written on methods of teaching the subjects as a manual shop course, but very little of real importance has been written on the teaching of their uses as applied to engineering. The engineers who have kept abreast of the times are aware of the developments in engineering which have required many engineers to apply welding and heat treating without having obtained the scientific knowledge necessarily needed for best results, and many serious failures have occurred for which there is no excuse. That is a reason why we should revise our teaching methods in shops and laboratories. They should be taught on the basis of applied engineering and not as a manual shop as most institutions are doing. This can be done without destroying the necessary manual operation needed to train the student.

Many of our students finish their intended engineering course without knowing the origin of tools or materials. The technical side of welding and heat treating is usually taken as a matter of fact, but too complicated for the average engineer to meditate over. Why? Because he has not been taught to apply his theoretical knowledge of chemistry, physics, metallurgy, design, strength of materials, etc., in such a way that he is able to accomplish his work intelligently.

The question may now be asked: How, and by what methods may we develop the proper teaching system that will comply consistently with requirements of sound applied engineering?

For best results the instructors must have a thorough practical and theoretical knowledge, and understanding of, the various phases of welding and heat treating in all fields of engineering. An instructor so qualified will be able to firmly plant in the minds of the students why and when this or that is to be done. Everything that is done in engineering work has some reason behind it, and that reason should be given the student if we expect him to obtain the proper knowledge in welding and heat treating. Therefore, the main purpose of engineering shops and laboratories should be to develop a thorough understanding of materials and their relation to productive and fabrication processes.

The purpose as stated above may be accomplished by: (*a*) Imparting a working knowledge of mechanics, chemistry, metallurgy, metallography, heat treating, etc., as applied to various processes of welding and heat treating.

(*b*) Training a student to select the proper material, filler rods, equipment procedure, and to be able to operate in such a manner as to not seriously modify the chemical, physical or mechanical properties of the deposited or the parent metal.

(*c*) Training the student to use welding and heat treating intelligently in design.

(*d*) Training the student to inspect and supervise heat treating and welding fabrication.

These objectives are accomplished at the Georgia School of Technology, Atlanta, Georgia, by requiring the students to obtain a thorough knowledge of the following:

A. Welding Methods:
1. Forge welding
2. Thermit welding
3. Resistance welding
   - Spot
   - Butt
   - Flash
   - Seam
4. Flame welding
   - Oxyacetylene
   - Oxyhydrogen
   - Natural gas
   - Coal gas
5. Atomic hydrogen welding
6. Arc welding (D.C. and A.C.)
   - Carbon arc
   - Metallic arc
     - (*a*) Bare rod
     - (*b*) Wash coated
     - (*c*) Shielded arc

B. The principles of chemistry, metallurgy, metallography, physics and heat treatment involved in making a good fusion or bronze weld and in the cutting of steels.

C. The useful application of all necessary apparatus and materials.

D. The effects of heat on grain structure.

E. The effect of hot and cold working and welding of steels considering their chemical composition.

F. The meaning and interpretation of the A. S. T. M. and S. A. E. systems of steel classification.

G. The effect of rate of cooling through critical ranges of various materials.

H. The effects of welding on heat-treated steels.

I. The meaning and working principles of the Brinnel, Rockwell and Shore-Scleroscope hardness testing machines.

J. The applied uses of the various physical testing machines.

K. The description and meaning of crystalline struc-

* Associate Professor, Mechanical Engineering, Georgia School of Technology.

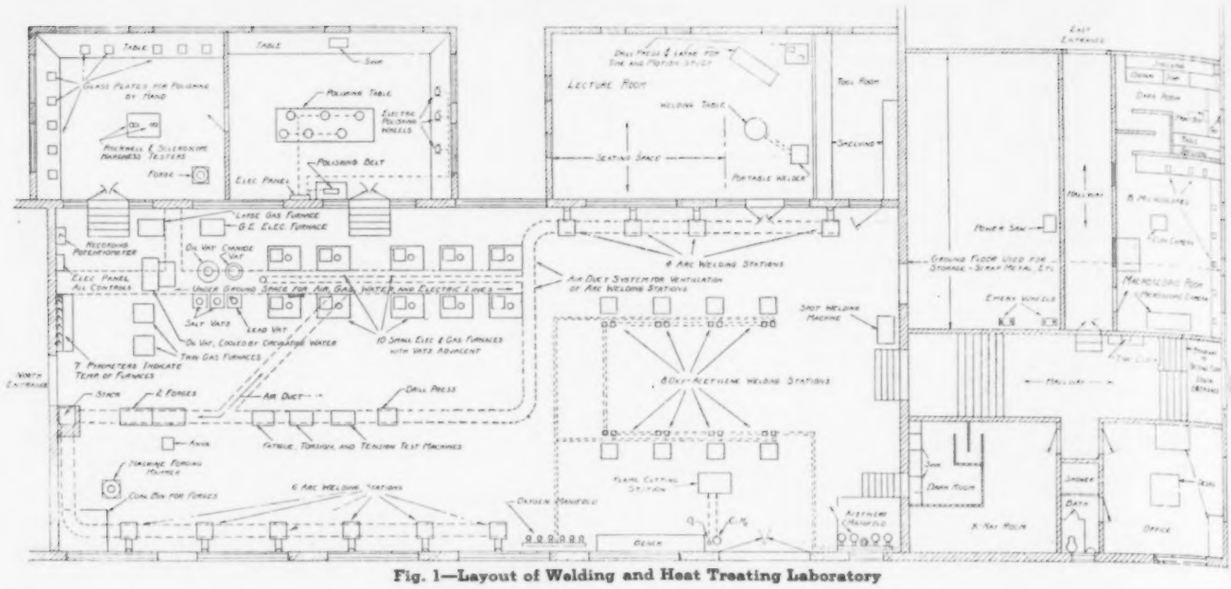


Fig. 1—Layout of Welding and Heat Treating Laboratory

tures such as Pearlite, Austenite, Sobrite, Martensite, Cementite, Troostite, Ferrite and Eutectoid steels.

L. The methods and procedures of heat treatment in both the hearth and bath furnaces.

M. The technique of polishing steel specimens and its importance.

N. The etching methods and the effect of various solutions.

O. The microscopic, macroscopic and microphotographic work encountered in the examination of steel samples.

P. The reading of microphotographic and X-ray films and interpreting their value from the metallurgical standpoint.

The courses of welding, heat treating and strength of materials consists of eight hours per week per semester for the mechanical engineering students, six of which are laboratory and two theoretical. The course as given to the electrical and civil engineering students consists of one lecture hour and three hours of laboratory per week per semester. The courses are presented by means of lecture and demonstrations and lantern slides. A thorough study of the advantages of strength, elimination of weight, and economy in proper designs is made.

Welding and heat treating processes, procedures and sequences to be followed in work such as pressure vessels, tanks, piping, ships, aircraft, machinery structural and bridge fabrications are discussed fully with the assistance of latern slides.

In this way the student will obtain the information needed, both practically and theoretically, as to the importance of knowing the principles related to working heat treating, welding, testing of materials and their classification as related to all fields of engineering.

The laboratory work, welding, heat treating and testing of materials, is taught by actual practice in following a definite procedure to bring to the student a mental picture of the uses, and factors that will effect engineering applications.

This is accomplished by actual practice in welding, heat treating and testing of various materials. The equipment used in our laboratories is as follows: Nine D.C. motor-generator arc-welding units, one superimposed high frequency 250 ampere A.C. unit, ten oxyacetylene units for heavy material and ten units for aircraft welding, one oxyacetylene flame hardening unit, one resistance butt and flash welder, one set of equipment for pipe-thermit welding and one for heavy shafting. For heat treating: six electric and eight gas furnaces, five bath furnaces for case hardening and tempering, and one electric furnace used for determining critical points; all of which are equipped with the necessary instruments for recording temperatures. The polishing equipment consists of one belt sanding machine, three disk sanding machines, one high speed emery wheel and six automatic polishing and lapping machines. For testing: one Rockwell hardness tester, one Shore-scleroscope tester, one Brinell tester, one 100,000 pound mechanical tensile machine, one 60,000 pound hydraulic tensile machine, one torsion testing machine, one set of Aims and Berry gages and jigs for measuring stress and strains caused by expansion and contraction, etc., and one impact testing machine. For dark-room work: One Bausch and Lomb metallographic outfit complete with the necessary optical equipment needed to obtain a magnification range of from fifty to 10,000 diameters, eight metallographic microscopes complete with objectives and eye-pieces to obtain magnifications ranging from ten up to 500 diameters, and one 200,000-volt X-ray unit. We also have the necessary dark-room equipment to train students in the principal methods and importance of proper precautions to be used in metallographic and X-ray photography.

By following a properly outlined laboratory course that will require the use of the above named equipment, as conducted by the Mechanical Engineering Department of the Georgia School of Technology, the students will acquire the knowledge as to proper design to comply with the required specifications. In that way he will obtain such items as: (1) Cost of preparing material, (2) Cost of fabrication, (3) Cost of handling, (4) Appearance of finished product. These items apply to the details and have an important bearing on the total cost, especially in production work.

The students are first taught the technique involved in the various methods of welding, heat treating and testing of materials, microscopic and macroscopic examinations, metallographic and X-ray work.

They are then assigned to various processes of work in squads consisting of three groups. The experiments involved the welding, heat treating and testing of properties of various materials. The results of their experi-

ments are assembled in one report. For example, they may be given seven 505 test specimens of S.A.E. 1010 steel for tests to be conducted as follows: Heat treat one at 1650° F., and one at 1900° F., quench in water at room temperature; carburize one at 1650° F., quench from box in water at room temperature then temper at 500° F., in oil or salt bath; two of which are welded by the shielded-arc process; and two are arc welded by the oxyacetylene process; then X-ray examinations are made of each weld. A specimen of each type of weld is then heat treated, either annealing or stress relieving as may be desired.

The various heat treatments as stated are conducted to obtain normal and abnormal structures for microscopic examinations. The purpose of this is to give the students an understanding of the importance of proper welding and heat treating procedure and its effect on physical properties and metallurgical constituents.

On the end of each test specimen there is a sample piece for microscopic examination which is removed before the physical tests are run.

When the material has received the designated heat treatment and physical tests, the results are written up in a report according to the following outline:

Experiment No. Date

1. Squad No.
2. Kind of material and its uses.
3. Chemical analysis.
4. Physical tests
5. Treatment of steel.....
   (*a*) Hot worked
   (*b*) Cold worked
   (*c*) Welding process
   (*d*) Heat treatment
6. Etching solutions used.
7. Microphotographs and magnification.
8. Discussion of structures
9. X-ray photographs.
10. Discussion of the radiographs.
11. Data and necessary graph charts.
12. Complete discussion of the entire report.
13. Remarks.

Experiments of this nature run on various materials, making a careful study of structures and physical properties, will determine the weldability of materials. In addition to the above we conduct experiments that include heat treatment and metallography study of the following materials:

(*a*) Plain and special carbon steels
(*b*) Alloy steels
(*c*) Alloys (such as bearing materials)
(*d*) Pure aluminum and aluminum alloys.

These samples are prepared in the laboratory, and a microscopic study made at various magnifications.

Critical Point curves are run by the Leeds and Northrup Difference Thermocouple methods for determining thermal critical points in Iron, Steels and Alloys. From this study the students are taught to understand the equilibrium diagrams of Iron, Steels and Alloys.

The understanding of these experiments makes it possible for them to see why various temperatures and quenching mediums will result in so many different structures in steels due to decomposition of crystals of solid solution-forming different constituents, such as ferrite, cementite, pearlite, austenite, martensite, troostite, sorbite, etc. These experiments show the effect that the alloys have on the constituents and thermal critical points.

In connection with the above, a careful study is made of the effect of common ingredients and alloys in steels, as related to forging and physical properties. This is accomplished by special etching solutions, making macroscopic and microscopic examinations at various magnifications, and by the making of various physical tests, and X-ray study.

In the welding laboratory, special problems are assigned to each student, involving the use of all equipment on a variety of materials, such as Low-Carbon and High-Carbon Steel, Grey, Cast and Malleable Iron, Alloy Steel, Bronze, Brass, Monel, Aluminum, etc., ranging from gage material to 1 inch in thickness.

A part of this work is required to be welded in jigs. By the use of certain designed jigs, they are shown how it is possible to step up production, cutting down fabrication costs, and at the same time obtaining satisfactory and accurate results.

For example, in welding No. 24 gage sheet metal, as used in the automotive industries, with an aircraft torch, using size No. 1 tip, and $^1/_{16}$-inch filler rod, we can successfully run 70 feet per hour. Whereas, in a revised method, using a properly designed jig, No. 6 tip, and $^3/_{16}$-inch rod, we can run 350 feet per hour.

The above experiment is also conducted in the electric arc process.

The results of these experiments are adequate for obtaining a knowledge of costs and production.

We find that the students take a great interest in experiments of this nature. Due to the great variety of welding applications, in which various types of welds are made in all positions, it is practically impossible to give exact procedures for each application, however, the general procedure which we follow in our experiments are adapted to most any type of work. In this way it is our opinion the students will obtain the proper engineering information and by careful study of the general procedure they will be able to modify the operation to meet required quality of weld desired, the fit-up, and the rate of dissipation of heat into members to be joined.

The following examples illustrate some of the methods as used in our laboratories for conducting experiments in welding and its relation to the heat-treating applications to be followed.

The heat-treatment of steel begins in the roller mill, where the tapping, rolling and finishing temperatures may have a great influence upon the characteristics of welding and what can be done to improve its structures by subsequent heat operations.

We may state at this time that heating, working and welding of steel in any form will impart some form of heat treatment to the steel. In that this is true, it is very important that our students should have a thorough understanding of physical Metallurgy.

We attack this problem by first giving them a few common definitions for heat-treating, working and welding of steel, and a discussion of the difference between the various phases in relation to such properties as tensile strength, hardness, impact resistance, as well as mechanism of the changes produced.

For the benefit of the Industrial City, and of the Souths advancement in the industrial field, we have added a course for qualifying welding operators to our Evening School of Applied Science. This was done to render help in giving our welders correct methods and a thorough knowledge of how to handle the different metals when welding is desired. We feel that this has helped to improve and advance welding on an economical basis.

In conclusion, the writer wishes to state that these courses are revised each year to keep abreast of modern development in engineering.

WELDED STEEL PIPE FOR THE City of Toronto Water Works Extension*

By CARL R. WHITTEMORE†

A VITAL factor in the life of mankind is an abundant supply of pure and fresh water which must be conveyed by some means to the points of consumption. The term "aqueduct" embraces all types of artificial works designed for the purpose of conveying water from one place to another. Generally the term is applied only to works of considerable magnitude.

Cast-iron water mains have been and continue to be widely used throughout the world with varying degrees of success, depending upon the nature of the soil and the character of the water conveyed. In recent years the following economical limitations have been placed upon cast-iron pipe:

1. A maximum diameter of 36 inches.
2. Pressures not in excess of 180 lb. per sq. in.
3. Uncertain resistance to pulsations caused by water-hammer and stress of "street conditions."
4. Decrease of carrying capacity with age due to tuberculation and incrustation.

In recent years, particularly in active water areas, the use of cement or concrete lined pipe has increased due to the appreciation of the fact that what is really being purchased is water carrying capacity. The composite steel concrete lined pipe permits more economical laying than either the reinforced concrete or cast-iron pipe since lengths up to 36 ft. are readily fabricated.

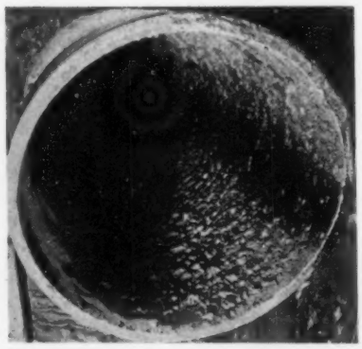


Fig. 1—Tuberculation and Incrustation of Cast-Iron Pipe

FABRICATION OF 48-INCH INTERNAL DIAMETER PIPE

The design, fabrication and installation of approximately 38,380 lin. ft. of 48-inch internal diameter steel-cylinder reinforced concrete pipe comprises part of the Toronto water works system as originally decided upon in general principle in 1926 under the direction of R. C. Harris, Commissioner of Works. This scheme selected Victoria Park as the proper location for a raw water intake and the above pipe line comprises the distribution main from this point to the existing system at Dupont Street and Davenport Road, which supplies the St. Clair Avenue-Spadina Road reservoir.

In December 1936, the Corporation of the City of Toronto called for tenders for riveted steel pipe, or alternatively electrically-welded steel pipe, concrete lined and when laid, encased in concrete. The general contract for supplying and laying the pipe was awarded to the Atlas Construction Company who called for tenders for fabrication of the pipe and joining of the pipe lengths in the field.

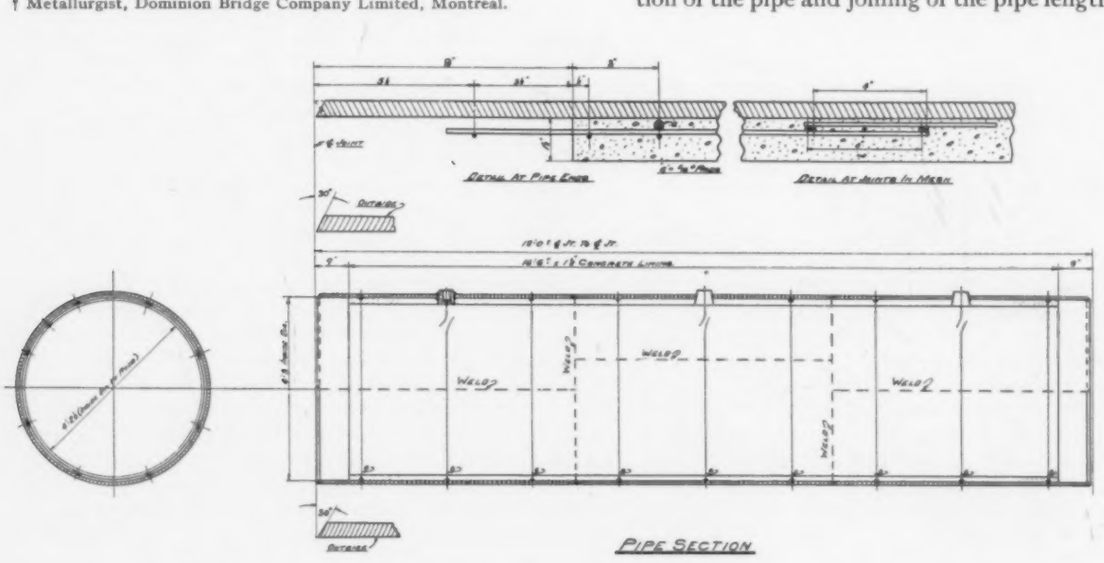


Fig. 2—An 18-Ft. Pipe Length Illustrative of the Design

* Abstracted from the Engineering Journal of Canada.
† Metallurgist, Dominion Bridge Company Limited, Montreal.

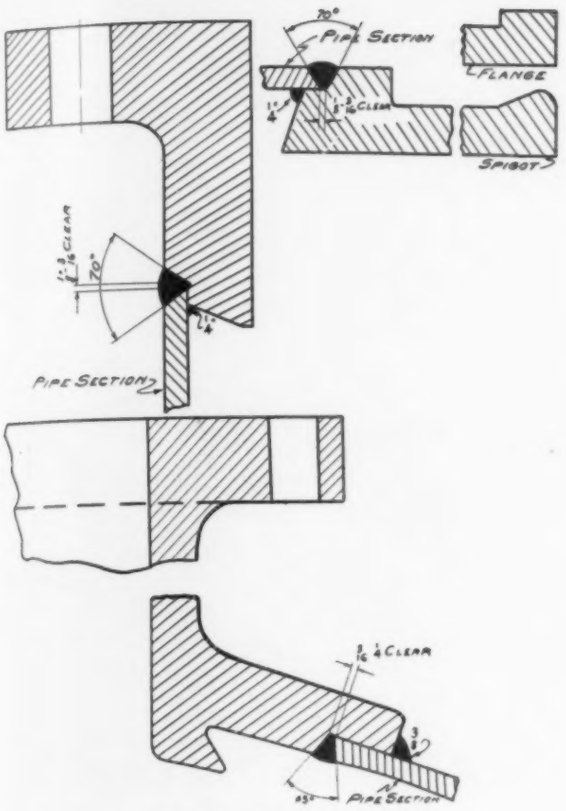


Fig. 3—Joint Details for Fittings

This portion of the work was awarded to the Dominion Bridge Company, Toronto, in March 1937, who tendered on a shop-welded steel pipe centrifugally concrete lined and welded field joints. All welding was to be in accordance with the American Society of Mechanical Engineer's Welding Code for Unfired Pressure Vessels, paragraph U-69 (formerly Class 2).

In manufacture and installation three general types of pipe are recognized: standards, specials and bends. Standards are made in 12, 18 and 30 ft. lengths. The 12 and 18 ft. lengths for the tunnels and shafts are made of $^{9}/_{16}$-inch plate, six feet wide, thereby requiring one and two circumferential joints, respectively. The 30 ft. lengths four open trench work comprise the majority of the pipe lengths and are made of $^{1}/_{2}$-inch plate, 6 ft. wide, thus requiring four circumferential joints. Specials comprise closing sections, tees, straight sections jointed at an angle, reducing sections, etc.

All standard pipe lengths are automatically metallic arc welded. Straight pipe sections are centrifugally concrete lined while all others and the field joints are lined with gunite.

TRAINING AND QUALIFYING WELDING OPERATORS

Upon the decision to electric arc weld the field joints it was fully appreciated that competent welding operators would not be available and that training would be necessary. It was, therefore, decided to form a welding school to specifically train men for hand welding the specials, bends and field joints.

From the class twenty-two men were qualified, in accordance with the Code, in the flat position and ten of these in the vertical position. In no case was there a failure of an individual test in the flat position and no complete failure in the vertical position.

With the careful selection of the welding personnel, thorough training and qualified supervision at all times, the "human factor" element was reduced to a minimum.

At no time should a welder be employed merely upon his claim of years of experience in arc welding. While the welder's claim may be quite correct for one class of work, he might be unable to perform the work required. Each man should be given a suitable preliminary test to ascertain his ability to weld on the flat and in the vertical position.

FABRICATION OF STEEL SHELL

Material

Steel Plate.—Steel plates $^{1}/_{2}$ inch and $^{9}/_{16}$ inch in thickness were purchased to specification A. S. T. M. A78-33, Grade B, covering plates of structural quality for forge welding, except that a tensile strength of 55,000 lb. per sq. in. minimum was required. The average chemical composition was—carbon 0.20 per cent, maganese 0.43 per cent, phosphorus 0.014 per cent, sulphur 0.043 per cent. Physical properties averaged 36,690 lb. per sq. in. yield point, 60,750 lb. per sq. in. tensile strength, 29.0 per cent elongation in 8 inches.

DESIGN

The steel cylinder, 51-inch internal diam. is designed and fabricated to withstand all stresses due to internal pressure while the concrete lining with wire mesh reinforcing provides permanent protection and maintenance of high water carrying capacity. Figure 2 shows an 18-ft. pipe length which is illustrative of the design.

The pipe lengths in the open trench are fabricated of $^{1}/_{2}$-inch steel plate which at 195 lb. per sq. in. test pressure produce a unit stress of 10,000 lb. per sq. in.

The pipe lengths for the tunnel and shaft sections, specials and bends are fabricated of $^{9}/_{16}$-inch steel plate which at 255 lb. per sq. in. test pressure produce a unit stress of 12,500 lb. per sq. in.

Air valve connections, drain nozzles, the ends of the steel pipe and pipe specials requiring connections by Victaulic couplings, manholes and flanges are of cast steel and designed for butt welding to the steel shell as illustrated in Fig. 3.

The use of steel plate insures convenience and adaptability in meeting almost any condition of construction

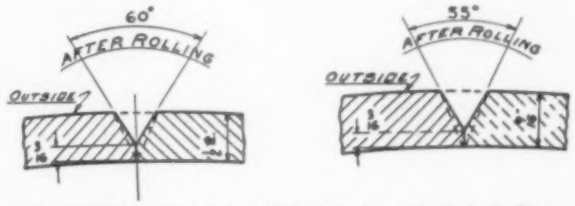


Fig. 4—Unionmelt Longitudinal Joint $^{1}/_{2}$- and $^{9}/_{16}$-Inch Plate

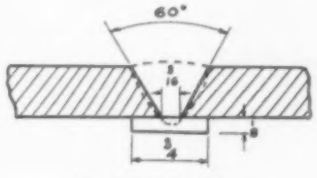


Fig. 5—Joint Design

required in the field. Therefore, all bends, both horizontal and vertical, are of the welded segmental type, and fabricated in the shop for all angles over one degree. They are made symmetrical, with each deflection an even degree, to simplify manufacture; that is, a 90° bend would be made up of deflections as follows: 8 at 5°, 1 at 4°, 1 at 2°, 1 at 4° and 8 at 5°.

Joints

The edges of plates $^1/_2$ inch and $^9/_{16}$ inch in thickness, which are to be automatically welded by the Unionmelt Process, are bevelled to form a 60 and 55° vee, respectively, with a $^3/_{16}$-inch lip as illustrated in Fig. 4.

The plate edges forming the field joints of all horizontal pipe are fully bevelled, inside for the lower half and outside for the upper half of the circumference, at an angle of 30°. Figures 2 and 5 show the joint design.

The pipe lengths for the shafts require that the field joint be fully welded from the inside. One end of each pipe length is 90° to the vertical axis while the opposite end is fully bevelled to an angle of 45° with the vertical axis. Two pipe lengths are assembled to form a joint as illustrated in Fig. 6.

All specials and bends are made up of segmental sections, manually metallic arc welded. The edges of the adjoining sections are fully bevelled to form a 60° vee, as shown in Fig. 7, for both circumferential and horizontal joints.

Plate Edge Preparation

The edges of the plate are prepared for automatic or hand welding by planing and by machine gas cutting. The plate as received from the mill is squared from one long side and end, then marked to length. The sides of the plate are next prepared by two Niles Bement Pond plate planers. The plate is not planed to a given width since closing pieces are used in the pipe line wherever required.

After the sides are prepared the plate is set up to stops on a table and one end cut and bevelled in the same operation using a special gas cutting machine (Fig. 8). The plate is then turned around, cut to length and bevelled, also, in one operation.

The machine is essentially a standard cutting machine with plate edge bevelling attachments which permit a uniform bevel cut since the guide wheel follows the contour of the plate. The commercial success of simultaneous cutting and bevelling depends primarily on the condition of the slag formed and its ease of removal. The control of the slag is governed by the velocity of the cutting oxygen stream and the bevel cutting reaction temperature. The smoothness of the gas cut edge is influenced by the preheat flames of both blowpipe nozzles.

The edges of the plate are next ground by an electric hand grinding wheel for a distance of about one inch from the edge for the purpose of removing mill scale which would contaminate the weld metal.

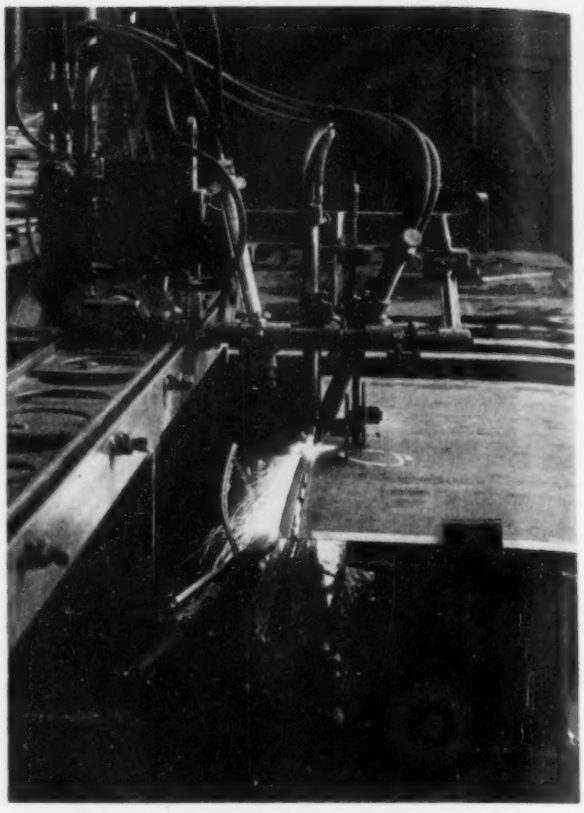
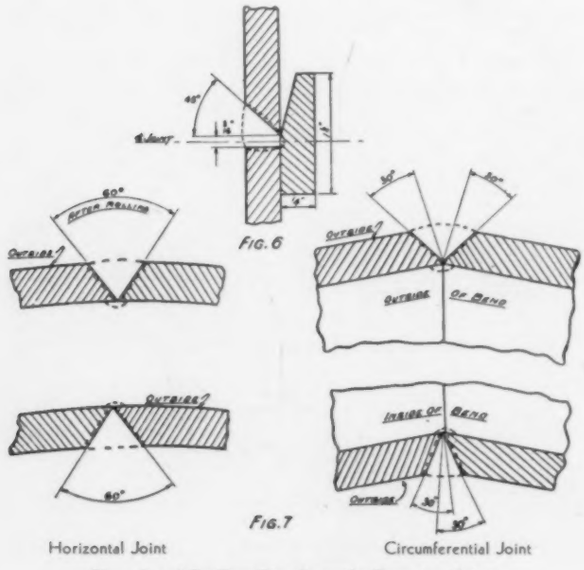


Fig. 8—Special Gas Cutting Machine Which Cuts and Bevels at the Same Time



Figs. 6 and 7—Two Pipe Lengths Forming Joint

ROLLING

The plates are rolled on a ten-foot Bertsch Roll, equipped with a hydraulic drop housing which permits quick removal of the rolled plate. As the plate must be formed accurately, no flat spots at the joint being permitted, the first operation is to break one plate edge for a distance of six to seven inches by entering the plate at the rear of the rolls. The plate is then removed by reversing the rolls, the formed edge entered from the front of the machine and the plate rolled to the required diameter in two or three passes. This gives a true circular pipe.

ASSEMBLY FOR LONGITUDINAL WELDING

The plate edges of a six-foot can section are placed in alignment and tacked together at 12 to 18-inch intervals. At either end of the section a steel tab, 8 inches wide by 4 inches long by the thickness of the shell and curved to its radius, is solidly welded for the starting and finishing of the electrode and to prevent the weld from cracking longitudinally at the finish.

Fig. 9—Clamps for Lining Up Plate Edges

Figure 9 shows the clamps for lining up the plate edges and taking out any twist due to rolling. The plate edges are made flush on the underside by jacking the edges into position and tacking on the groove side. The assembled can section is now ready for automatic welding.

Trueing

The operations of trueing and assembly for circumferential welding which follow the longitudinal welding are now considered in order to maintain continuity in describing the automatic welding process.

The longitudinal welding tends to peak the can section along the welded joint. In order to obtain proper joints for circumferential welding it is necessary to make the can section truely circular by passing the welded seam between top and bottom dies radiused to the outside and inside diameters, respectively, of the pipe.

Assembly for Circumferential Welding

The six-foot can sections are assembled end to end on a roller bed to form 12, 18 and 30-ft. pipe lengths as required.

Assembly rings are placed in one section of the pipe, the next section of pipe is slipped over the ring with the longitudinal seam offset six inches from that of the previous section. The next ring is similarly placed on and the longitudinal weld placed in line with the first pipe section. When the required number of sections are placed together they are drawn tight by means of clamps and the joints tack welded at intervals of about 18 inches. The pipe is now ready for the circumferential welder.

AUTOMATIC WELDING

One means of providing protection to the metal being deposited is to cover the seam to be welded with finely divided flux material and to feed by conventional means a bare wire electrode, striking the arc under the powdered flux. Although this method has been known for several years it has not, until recently, met with much success owing to the variable porosity resulting from the type of flux and comparatively low currents used.

Realizing that the principle of such a method would be of great economic importance if welded joints conforming to the A. S. M. E. Code for power boilers and unfired pressure vessels could be made, the Union Carbide and Carbon Corporation investigated the method and over a development period of four to five years succeeded in meeting Code requirements and in welding greater plate thicknesses in a single pass than formerly, viz. above $^1/_2$ inch. This process will hereinafter be referred to as the Unionmelt Process.

The Unionmelt Process provides a process by which plates up to and including two inches can be welded in a single pass at speeds greater than any other automatic process. Plates over two inches are welded in a plurality of passes. The welds thus produced are equal in density and physical properties to the parent material. The process also eliminates arc blow and avoids the necessity for flux covering the electrode.

The above results are accomplished by the use of high currents and a flux or welding composition which forms a high resistance melt providing heating means, controlling the welding speed, the penetration, the quality of weld and protecting the molten metal.

The properties of a welding composition capable of producing quality welds must fulfil the following requirements:

(*a*) Complete the chemical reactions between the components of the melt, otherwise porosity will result.
(*b*) Must be capable of controlling the penetration and width of weld.
(*c*) Fluidity at welding temperatures must be such that it will not be entrapped in the molten metal.
(*d*) Chemical elements must not be detrimental to the weld metal.
(*e*) Resulting slag must be readily removable from the finished weld.

The above requirements are fully embodied in the Unionmelt welding composition. A process so different to other automatic processes naturally requires innovations in the design of equipment, joints and operating technique.

EQUIPMENT AND MATERIALS

Welding Head

The source of welding current may be either direct current or alternating current. The former is used by Dominion Bridge Company Limited and is supplied by

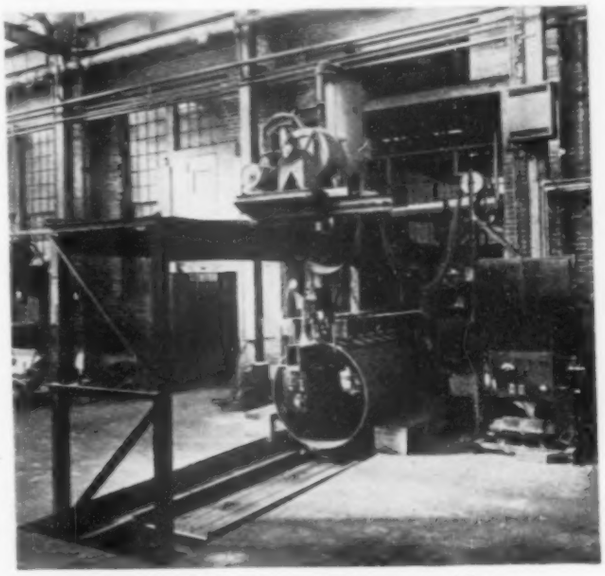


Fig. 10—Welding Fixture for Longitudinal Seam

two standard 600-ampere welding machines connected in parallel.

The welding head is designed to feed the electrode automatically, and to conduct current to the "bare" wire electrode. The welding head and flux hopper are mounted on a travelling carriage.

Welding Flux

The flux, which at all times covers and surrounds the electrode, is fed down through a tube from the hopper. The amount fed is regulated by a small adjustable valve at the end of the tube and distributed to an even height and width during welding. Immediately behind the completed weld a suction tube picks up the unused flux and returns it to the top of the hopper in which a screen is inserted for the removal of partially fused particles. Ahead of the completed weld and running in the joint are two guide rollers which keep the electrode in the proper relative location to the seam being welded. These rollers operate integrally with the welding head.

Electrode

The electrode is a "bare" metal electrode, $^1/_4$ inch in diam., with a copper finish for protection from rusting. The chemical composition is carbon 0.12 per cent, manganese 0.97 per cent, silicon 0.30 per cent, sulphur 0.0266 per cent. The electrode is furnished in coils of 150-170 lb.

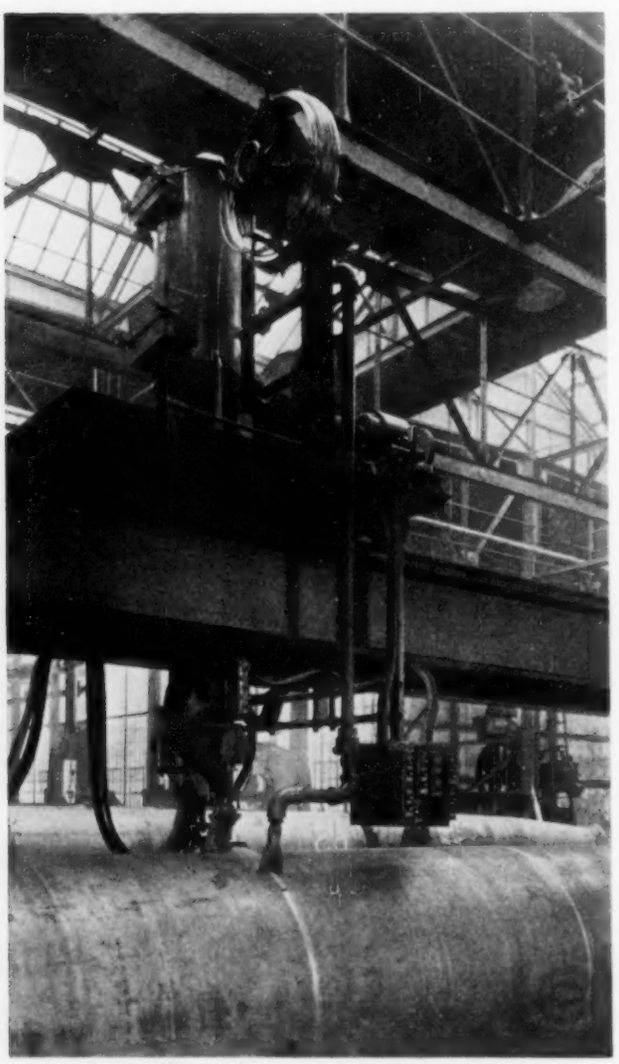


Fig. 11—Welding Fixture for Circumferential Seams

Fig. 12—Transformation Zones on $^9/_{16}$-Inch Pipe

Fixture for Longitudinal Seam

The welding fixture for the longitudinal seam comprises a welding head and flux hopper suitably mounted on a track over an air operated clamping fixture designed to accommodate a six-foot pipe section (Fig. 10).

The joint to be welded is backed up by a water-cooled copper backing bar which is attached by means of an arm to the travelling welding head and centered directly under the electrode.

In the welding of the longitudinal seam the pipe section remains stationary and the welding mechanism automatically traverses at a predetermined speed along the seam.

Welding Fixture for Circumferential Seams

The fixture for welding the circumferential seams accommodates a 30-ft. pipe length and comprises a rotating mechanism over which is mounted a steel framework carrying the welding head and flux hopper (Fig. 11). In this welding operation the head, having been previously set in the proper position over the seam to be welded, remains stationary, while the pipe revolves at the predetermined welding speed. When the electrode feed is started, power is simultaneously applied to the rotating mechanism and the pipe revolves.

Welding Technique

It is essential that the plate edges, prepared as shown in Fig. 4, be tight throughout their entire length and flush on the underside, this being obtained as described under Assembly for Longitudinal Welding.

The flux composition when cold is non-conductive and to provide a conductive path for the current the gap between the electrode and the work is bridged by a ball of steel wool about $^1/_2$ inch in diam. Flux is then fed around the electrode and the power applied. The flux is locally heated until it fuses and becomes conductive, forming a subsurface pool and immediately thereafter the end of the electrode fuses and the molten metal begins to deposit in the groove, displacing the subsurface pool of fused flux. At the same time the plate edges fuse and coalesce with the metal deposited as the electrode continues to feed under a protective layer of flux. About one minute after completion of the weld the fused slag covering lifts away from the weld exposing a clean and uniform surface.

The weld quality is influenced by the voltage difference between the electrode and the work, by the current, the size of electrode, the rate of feeding the electrode and the speed of travel along the seam. Keeping the welding speed constant, the arc voltage and current vary with the plate thickness, each being a function thereof. The proper welding current for a given plate thickness is a function of the diameter of the electrode, the degree of penetration, rate of deposition of metal, welding speed and the composition of the flux.

Welding conditions for $^1/_2$-inch and $^9/_{16}$-inch plate are as follows:

Plate Thickness, Inches	Current Amperes	Arc Voltage	Speed Inch per Min.
1/2	900	32	14
9/16	920	32	13
	900	32	12

These conditions in conjunction with the proper design of backing-up bar produce full penetration with a slight reinforcement on the underside. If at any point in the weld length penetration is lacking the unfused portion is chipped out and rewelded by hand.

With sufficient welding generator capacity the welding currents and speeds may be increased to 1075 to 1175 amperes and 20 to 23 inch per min. for 1/2-inch plate, and 1150 to 1200 amperes and 16 to 19 inch per min. for 9/16-inch plate without affecting weld quality.

METALLURGICAL EXAMINATION OF UNIONMELT WELDED JOINT

The chemical and physical properties of the plate material conforming to A. S. T. M. Specification A78-33, the weld metal and the welded joint are as follows:

1/2-Inch Welded Plate

Plate Material

Chemical Composition		Physical Properties	
Carbon	0.18%	Yield point	37,140 lb. per sq. in.
Manganese	0.44%	Ultimate strength	60,920 lb. per sq. in.
Phosphorus	0.016%	Per cent elong. in 8 in.	29.0
Sulphur	0.04%		

Weld Metal

Chemical Composition		Physical Properties—as welded	
Carbon	0.15%	Yield point	42,600 lb. per sq. in.
Manganese	0.37%	Ultimate strength	70,600 lb. per sq. in.
Silicon	0.14%	Per cent elong. in 1 1/2 in.	22.0
Sulphur	0.033%	Per cent reduction of area	29.4
		Impact—Charpy	
		Transverse	29 and 33 ft. lb.
		Longitudinal	17 and 22 ft. lb.

Welded Joint

The following physical tests, non stress-relieved, in accordance with paragraph U-69 A. S. M. E. Code requirements are representative of those made during progress of fabrication:

Reduced Tensile

No.	Ultimate Strength Lb. per Sq. In.	Remarks
1	62,389	Fracture in plate 1 1/4 in. from weld
2	60,824	" " " 1 1/4 " " "
3	59,452	" " " 1 3/8 " " "
4	59,685	" " " 1 1/4 " " "

Free Bend

No.	Per Cent Elongation of Outside Fibers	Remarks
1	60.5	No failure, no fracture, 180 deg. bend
2	62.5	No failure, no fracture, 180 deg. bend
3	51.2	No failure, no fracture
4	43.9	No failure, no fracture

9/16-Inch Welded Plate

Plate Material

Chemical Composition	Per Cent	Physical Properties
Carbon	0.20	Yield point—39,220 lb. per sq. in.
Manganese	0.54	Ultimate strength—63,150 lb. per sq. in.
Phosphorus	0.03	Per cent elongation in 8 in.—27.5
Sulphur	0.04	
Silicon	0.02	

Weld Metal

Chemical Composition	Per Cent	Physical Properties—as welded
Carbon	0.17	Yield point—62,000 lb. per sq. in.
Manganese	0.70	Ultimate strength—78,000 lb. per sq. in.
Silicon	0.34	Per cent elongation in 2 in.—21.0

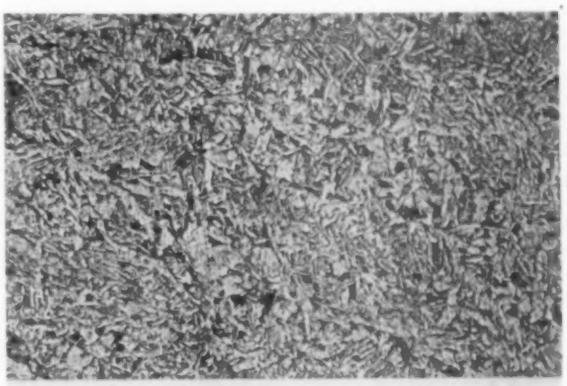


Fig. 13

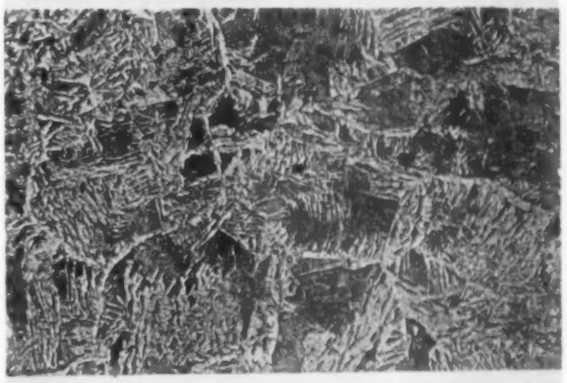


Fig. 14

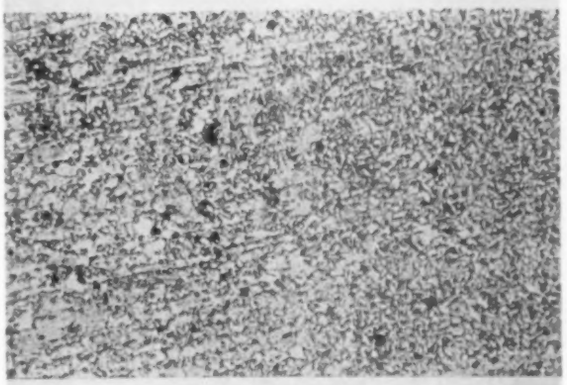


Fig. 15

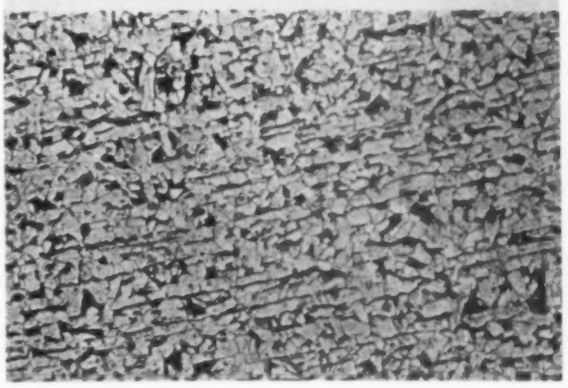


Fig. 16

Figs. 13, 14, 15 and 16—Microstructure of Weld Metal Transition Zone and Parent Plate

Fig. 17—A Typical Bend

Welded Joint

Forward bend	48.5 per cent elongation of the outside fibers, no failure, no fracture, no porosity.
Back bend	180 deg. without evidence of fracture, porosity or slag inclusion.
Nick break	Uniform crystalline structure—no slag—no porosity.
Exograph	The exographs show no porosity, no slag and no lack of fusion.

Hardness

Scleroscope hardness readings taken across the welded joint indicate only 1 to 2.5 points of hardness increase in the weld above that of the plate.

MICROSTRUCTURE OF WELDED JOINT IN $^{9}/_{16}$-INCH PLATE

The Unionmelt weld being a single pass weld for plate thicknesses up to and including two inches has certain distinguishing characteristics.

Microscopic examination of a cross section of the welds of different plate thicknesses shows that the planes defining the zone of fusion at the sides of the weld and the zone boundary of the transformed plate are approximately parallel. The microstructure of these zones throughout the cross-sectional area are very uniform, indicating that the heat conditions from the top to the bottom of the weld do not differ greatly. Such a condition materially decreases the unequal stresses and lessens the distortion of the plate.

The following microstructures are typical of welds made by the Unionmelt Process of $^{9}/_{16}$-inch and $^{1}/_{2}$-inch plate.

Figure 12 shows diagrammatically, the extent of the transformation zones on $^{9}/_{16}$-inch plate.

Figure 13 shows the microstructure at a magnification of 100 times of the weld metal. It is a fine cast structure composed of pearlite and ferrite uniformly distributed.

Figure 14 represents the microstructure at a magnification of 100 times of the transition zone adjacent to the weld metal.

Figure 15 represents the microstructure at a magnification of 100 times of the transition zone adjacent to the plate. The structure has been refined at a temperature of 1500–1550° F. within the thermocritical range.

Figure 16 shows the microstructure at a magnification of 100 times of the parent plate. The structure is typical of low-carbon plate comprising ferrite and pearlite (dark)

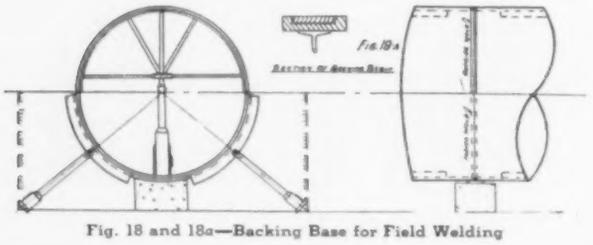


Fig. 18 and 18a—Backing Base for Field Welding

PIPE TESTING

The welded pipe length from the circumferential welding machine is inspected for visible defects inside and out, and the necessary repairs made. Small outlets, if required, are then welded in and the pipe made ready for the insertion of gaskets at either end for the hydraulic test.

The pipe is rolled into the press and the movable head set up to with $^{1}/_{16}$ inch of the pipe. The low-pressure filling pump is started and the air release valve opened permitting the air to be displaced by the filling water.

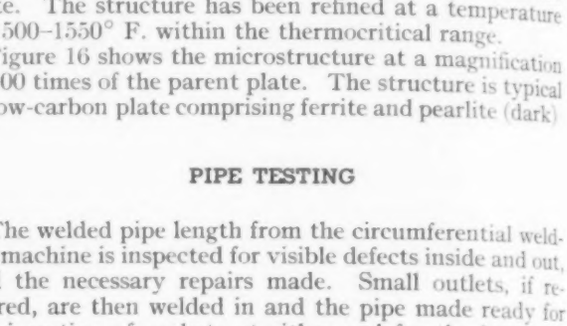


Fig. 19—Weld Metal Deposition Diagram for Circumferential Weld, Specials and Field Welding

When the pipe is full of water as shown by the escape of water from the air valve, the filler pump is stopped, the valve closed and the triplex pressure pump started. The pump is set to by-pass at the test pressure so that it can operate while the pipe under test is inspected for leaks. Pipes having a $^{1}/_{2}$-inch wall thickness are tested at 195 lb. per sq. in. pressure and those having a $^{9}/_{16}$-inch wall thickness at 225 lb. per sq. in.

The hydrostatic testing of the specials and bends presented a problem as regards evolving a quick and economical method. This was satisfactorily solved by clamping a wide band onto either end of the special or bend. The band is notched out at eight points equally spaced around the circumference and sixteen one and one quarter inch bolts welded to the band for attachment of a two-inch steel plate head with gasket. The clamp is firmly held by tabs welded onto the steel shell into which the notches fit. Upon completion of the test the head and clamp are unbolted and lifted off. The tabs are left on the pipe.

PIPE BENDS

The segments forming the bend are laid out to template on flat plate, cut to shape and bevelled by machine

gas cutting. The segments are rolled to the proper diameter and assembled in units which are easily turned by hand. These units are welded and then assembled to form the completed piece which is turned by crane so that welding may be done in a downhand position. The ends of the pipe bend are held circular by welding struts two inches in from either end. The bracing is left in until the bend is assembled in the field, then removed by gas cutting.

The design of the joint is shown in Fig. 7. The horizontal welds are first made, then the circumferential welds. A $^5/_{32}$ inch diam. covered electrode is used for the first pass and a $^3/_{16}$ inch diam. covered electrode for the subsequent three passes. Each deposited layer of weld metal is thoroughly cleaned by a Pneumatic Weld-Flux Chipper and wire brushed. The back of the weld is chipped out and a single pass weld made with $^3/_{16}$ inch diam. electrode.

Nozzle outlets or branches are then welded in place and the bend subjected to a hydrostatic test pressure of 255 lb. per sq. in. A typical bend is illustrated in Fig. 17.

After testing, wire mesh reinforcing is placed inside of the bend to within four or five inches of the ends and then lined with gunite to within nine inches of the ends. The mix used is 1 part of cement to 3.26 parts of sand by volume. This gives in place a mix of approximately 1 to 2.75. The compressive strength at the end of 28 days is approximately 5500 lb. per sq. in.

HAULING AND LAYING PIPE

After curing, and as required, the pipe is loaded on a truck equipped with cushioned bunks so as to minimize any shock occurring in transit, and hauled to the trench side. One pipe is carried at a time and upon delivery at the site the pipe is carefully unloaded from the truck by a caterpillar tractor crane. The unloading of the pipes at the site, the placing for jointing by welding, the encasing in concrete and backfilling were carried out by the general contractor.

The horizontal pipe lengths are placed on concrete blocks set to grade. At each field joint a steel plate 3 by $^3/_{16}$ by 14 inch formed to the contour of the pipe, is placed between the pipe and concrete block, central with the joint. The ends of the pipe are placed to within about $^3/_{16}$ of an inch and then jacked in or out as required to give a uniform gap of $^3/_{16}$ inch throughout the circumference. The joint is next backed up by inside and outside steel backing bars tightly jacked against the shell (Fig. 18). A steel strip three-quarter inch by one-eight inch is inserted in the backing-up bars (Fig. 18*A*) and is welded to the joint, thus providing complete fusion throughout the entire plate thickness. The joint is welded on the outside of the top half and on the inside of the bottom half simultaneously using $^5/_{32}$ and $^3/_{16}$ inch diam. covered electrodes. The sequence of deposition of weld metal is shown in Fig. 19. Upon completion of the welds the backing bars are removed and the junctions of the inside and outside welds gouged out. The joint is rewelded to ensure good weld metal.

It is of interest to note that the field welding was satisfactorily carried out during the winter months by enclosing each joint with a canvas canopy, pre-heating the joint and allowing it to cool slowly after welding.

Welding current is supplied by 300 ampere gasoline driven welding units. The fumes from welding are exhausted by a fan electrically driven by power supplied from the welding unit. The fan is located a few inches from the joint being welded.

The welded joint is next prepared for concrete covering with gunite.

ACKNOWLEDGMENT

The writer wishes to acknowledge gratefully the valuable assistance of C. H. Timm, A.M.E.I.C., and Mr. G. J. Price, of the Dominion Bridge Company Limited, in the preparation of this paper.

CARBURIZED WELDS

By E. J. WELLAUER* AND G. C. DOEHLER†

THERE are applications in the machinery field where welds are used on parts which are to be carburized. In these cases, problems arise which are not ordinarily encountered in carburizing. The following experimental information was obtained for the purpose of investigating the phenomena involved in carburizing weld metal.

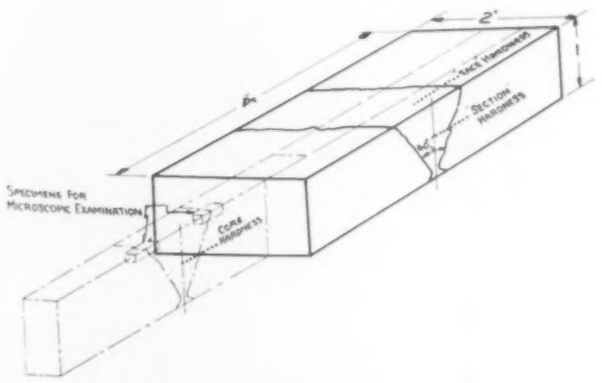


Fig. 1—Specimens Used in Tests

TEST PROCEDURE

The welds in the test joined forged and annealed S. A. E. 2315 Steel, a $3^1/_2$ per cent nickel steel, widely used as a carburizing steel for miscellaneous machine elements. The proportions of the weld are shown in Fig. 1. Two specimens were welded for each of four analyses of rods. One specimen was peened with an air hammer after each pass, the other specimen was not peened. The coated rods were $^5/_{32}$ inch in diameter, the current 140 amperes at 22 volts D.C. quality welding procedure was used with the most advantageous polarity, etc. being determined by preliminary tests. The analy-

* Metallurgist, The Falk Corp., Milwaukee.
† Engineer, The Hevi Duty Electric Co., Milwaukee.

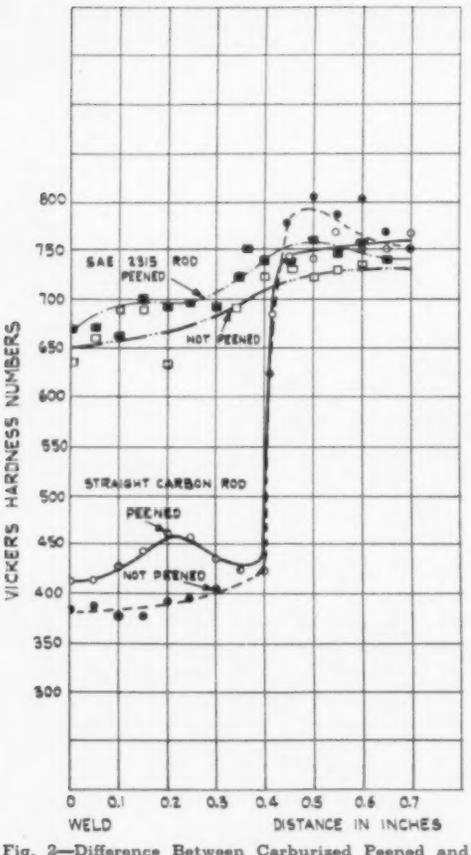


Fig. 2—Difference Between Carburized Peened and Unpeened Welds

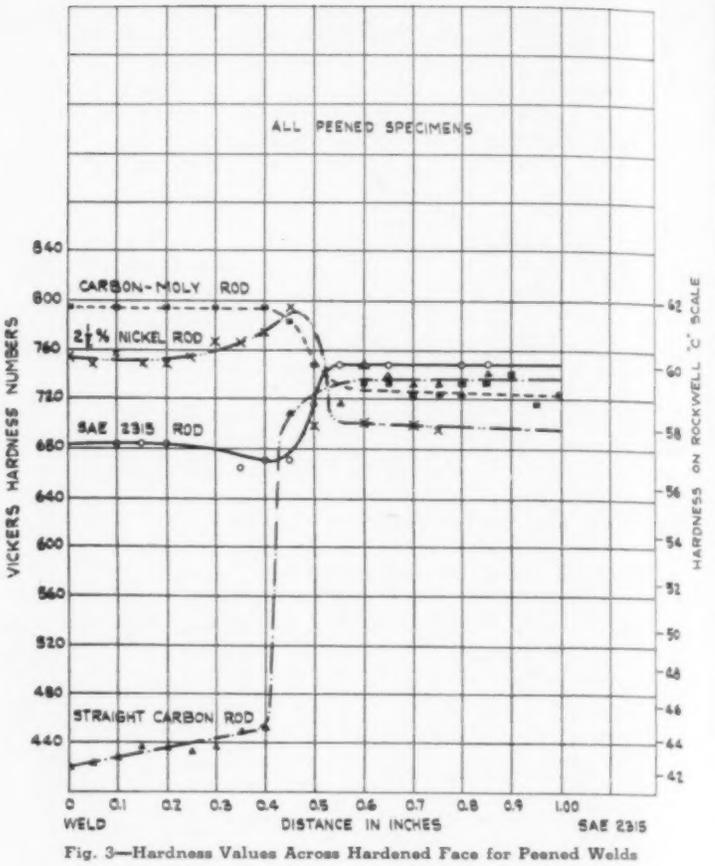


Fig. 3—Hardness Values Across Hardened Face for Peened Welds

sis of the rods and other pertinent data are included in Table 1.

The S. A. E. 2315 stock was forged and annealed. The welds were made and then normalized at 1650° F., after which the weld bead was machined level with the parent stock. The specimens were carburized for 10 hours at 1700° F. in a vertical retort furnace using a gaseous carburizing medium. The sections to be hardened were then oil quenched from 1425° F. and drawn at 350° F.

Table 1

Element	Parent Stock	2½% Nickel Rod	S. A. E. 2315 Rod	Straight Carbon Rod	Carbon-Moly. Rod
Carbon	0.15	0.08	0.17	0.08	0.12
Manganese	0.45	0.54	0.40	0.35	0.64
Silicon	0.23	0.08	0.15	0.06	0.08
Nickel	3.40	2.30	3.75	...	...
Molybdenum	...	0.29	...	...	0.48
Polarity		Straight	Reversed	Reversed	Straight

Table 2—Case Depths

Rod	Condition	Depth of Case in Weld	Depth of Case in Parent Metal S. A. E. 2315	Difference
2½ per cent Nickel	Peened	0.063 In.	0.075 In.	0.012 In.
	Not peened	0.073 "	0.080 "	0.007 "
S. A. E. 2315	Peened	0.100 "	0.070 "	0.030 "
	Not peened	0.104 "	0.075 "	0.029 "
Straight Carbon	Peened	0.058 "	0.075 "	0.017 "
	Not peened	0.060 "	0.075 "	0.015 "
Carbon-Moly.	Peened	0.060 "	0.075 "	0.015 "
	Not peened	0.062 "	0.080 "	0.018 "

TEST RESULTS

Growth.—Growth in section accompanies all carburizing reactions. In these tests, the weld metal averaged from 0.001 to 0.002 inch less growth than the parent metal.

Macro-Examination.—Cross sections of the welds were polished and acid etched. The following observations were made. The carbon-moly. and 2½ per cent nickel welds were uniform and very dense. As might be expected, the S. A. E. 2315 weld rod produced a relatively porous weld. The straight carbon welds showed the boundary marks of each weld pass. There was no noticeable difference between the peened and unpeened welds. It would seem that the carbon-moly. and 2½ per cent nickel rods produced the more desirable welds with the procedures used in this test.

Case Depths.—The case depth and variation between parent and weld metal are recorded in Table 2. With the exception of the S. A. E. 2315 rod, the carbon penetration into the weld metal was less than the penetration into the parent metal. The depth of carbon penetration was practically equal for the various rods, except for the S. A. E. 2315 rod. The greater penetration into the S. A. E. 2315 weld was probably due to the greater porosity of the weld. The carbon penetration into the peened and unpeened welds was practically equal.

Hardness Explorations.—Case carburizing is used for the purpose of securing a very high hardness on a specified surface. Where welds are a portion of the useful carburized surface, it is important that the hardness obtained be within the limits specified for the parent stock. For the hardness readings, a special micrometer screw was arranged on a Vicker's Brinell machine to read at each 0.050 inch. A 50 kilogram load was used to give

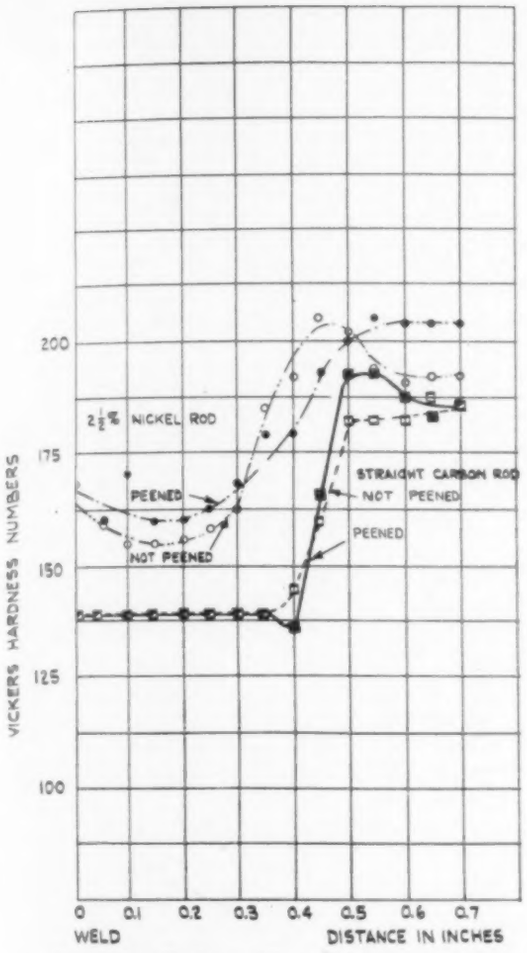


Fig. 4—Core Hardness of Peened and Unpeened Welds

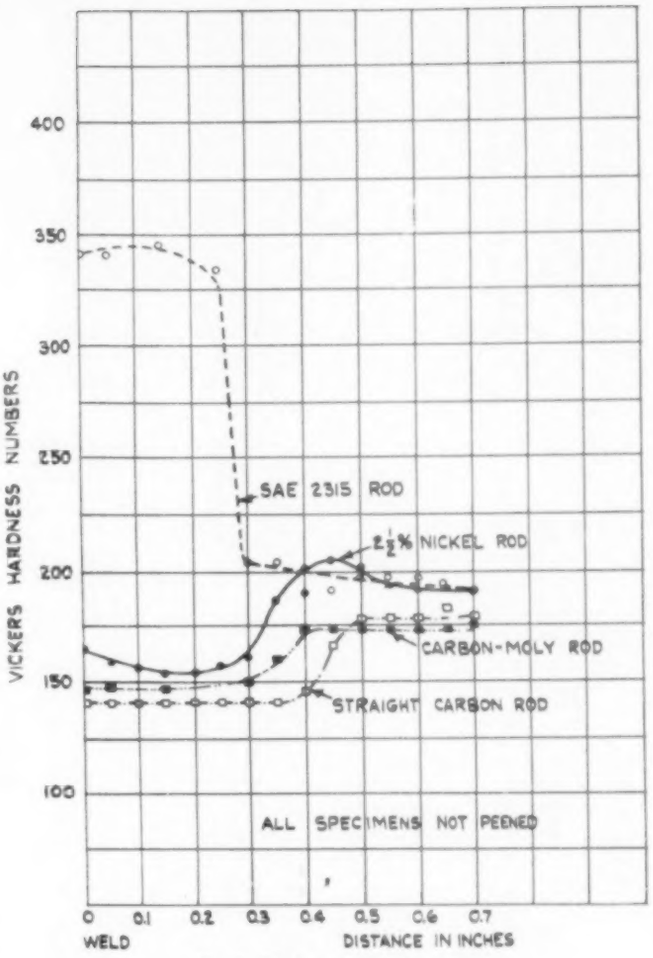


Fig. 5—Variations Between Rods

the necessary penetration. A complete hardness exploration was made of the face and section of the weld. It was found that hardness readings from the center of the weld to the parent metal gave a good indication of the hardness characteristics of the particular weld. These values are presented in the following data.

In the hardened case, the peened welds showed a slightly higher hardness than the unpeened welds, the difference not being sufficiently great to warrant the general adoption of peening. The typical difference between the hardened peened and unpeened case carburized welds (across the section) is illustrated by Fig. 2. A comparison between the hardness values across the hardened "face" for the various peened specimens is plotted in Fig. 3. There is but slight variation in hardness between the carburized "section" and the "face" of the weld. The alloy rods produce a case which matches the parent metal case hardness for most practical purposes. The straight carbon rod would not be suitable because the resulting case hardness is too low.

In the core, the hardness of the peened and unpeened welds after quenching were substantially equal as shown in Fig. 4. The variation between the various rods, unpeened, is illustrated in Fig. 5. With the exception of the S. A. E. 2315 weld, the core hardness of the weld was lower than that of the parent metal. The peened and unpeened S. A. E. 2315 welds had identical high hardnesses, indicating that the particular analysis undoubtedly absorbed some hardening element such as nitrogen, etc., during the weld process. The variations in core hardness are within commercial limits and will

Fig. 6—S.A.E. to 2315 Rod. X 50

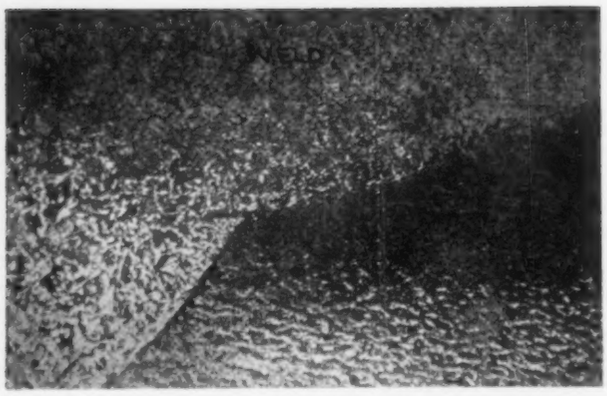


Fig. 7—Straight Carbon Rod. X 50

not affect the operation of the welded and carburized structures except for the S. A. E. 2315 rods. Actual experience has shown that the S. A. E. 2315 rod has doubtful merits for case carburizing applications when welded by standard practices.

Microscopic Examination.—A microscopic examination of the carburized welds revealed structures which ordinarily would not be suspected of existing. First, it was evident that the carburized microscopic structures on both sides of the junction of the weld were entirely different and very sharply defined even for the rod of the same analysis. Second, in the carburized weld metals, a large percentage of hypereutectoid zone was formed, whereas, there was very little, if any, hypereutectoid zone in the parent metal.

The sharply defined boundary between the different structures is illustrated in Fig. 6 for the S. A. E. 2315 weld rod. The dark portion is the eutectoid structure, whereas the lighter portion is the ferrite of the parent metal. The carbon has penetrated considerably deeper into the weld metal. The void shown is typical of the porous structure resulting with this rod. The same boundary and structural differences for the straight carbon rod is shown in Fig. 7. In this case, the carbon has penetrated deeper into the parent metal. It would seem that the carbon prefers to penetrate through the parent metal by a longer path rather than penetrate through the junction.

The great difference in the structures of the outer case, especially of the formation of the hypereutectoid structure is illustrated by Fig. 8. All the rods showed this characteristic. The formation of a hypereutectoid zone is to be avoided because such a case, although extremely hard, is also very brittle and susceptible to the development of cracks and grinding checks. As an average, the parent S. A. E. 2315 metal had a maximum hypereutectoid case of from 0.005 to 0.010 inches with 0.040 to 0.050 inches of eutectoid zone, whereas the weld metals had approximately 0.030 inches of hypereutectoid zone with an eutectoid region of only 0.035 inches.

There was no measurable difference between the peened and unpeened specimens in the formation of a hypereutectoid zone or in the presence of sharply defined boundaries.

Considerable grain coarsening occurred in the weld metal at the high carburizing temperature. Refinement was not secured with the single quench, as illustrated by Fig. 9. For purposes requiring a maximum core toughness, a double quench is recommended for the purpose of securing full refinement in the core of the weld metal and the parent metal if its composition is such as to permit grain coarsening at the high carburizing temperatures.

Several reasons may be advanced to explain the sharply defined structures. For example, Fig. 7—the $3^1/_2$ per cent nickel parent metal requires only 0.75 per cent of carbon to have the eutectoid content, whereas 0.83 per cent of carbon is required for the formation of the eutectoid structure in the plain carbon steel. This higher carbon content will occur nearer to the surface, which fact is substantiated by the photomicrographs. Therefore, with the same carbon content on either side of the weld junction entirely different metallographic structures may exist. This difference may cause internal stresses, etc. upon quenching and contribute as a primary source of failure. In fact, service failures of highly stressed carburized welds have been caused by a definite separation at the junction of the weld and parent metal.

It is difficult to correlate the deep hypereutectoid zone formation in the weld metal with diffusion rates in low-carbon steel. Actually, it is evident that in sound dense welds carbon penetration is difficult. In actual commercial practice, an attempt should be made to diffuse the hypereutectoid zone.

CONCLUSIONS

The results of these terms may be directly used for other than S. A. E. 2315 parent metal by making allowances for the difference in carbon content, rates of carbon diffusion, grain coarsening characteristics, etc.

A weld rod should be selected such as to produce the least variation in case and core structure and hardness between the weld and parent metal.

The coating should be of a composition which will minimize the introduction of dissolved gases particularly oxygen and nitrogen.

As verified by numerous experimenters, peening has no marked effect upon welds.

The selection of the carburizing process should enable the weld to be soaked at carburizing temperatures (without contacting the carburizing medium) in order to diffuse the hypereu-tectoid zone. A gaseous carburizing process is ideal for this purpose.

The carburizing temperature and heat treatment will depend upon the selection of the parent and weld metal. Details will be governed by the well known-principles applicable to all carburizing processes.

Fig. 8—Carbon-Moly. Rod (Case). X 100

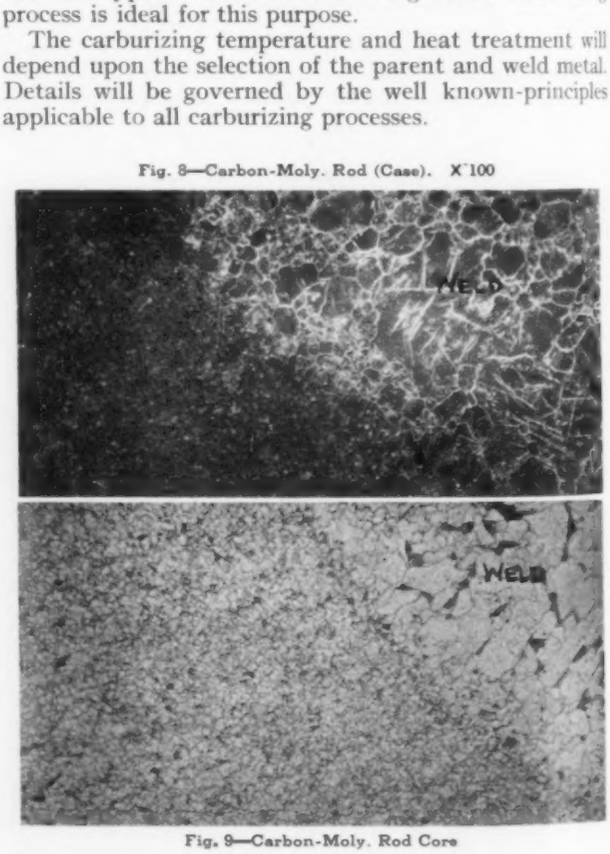


Fig. 9—Carbon-Moly. Rod Core

DATA ON SPOT WELDING OF 18–8

Stainless Steel to Yellow Brass

BY F. R. HENSEL,† E. I. LARSEN‡ AND E. F. HOLT**

INTRODUCTION

WITH the progress of resistance welding, problems arise more frequently where it becomes necessary to attach two pieces of dissimilar metals to each other by means of resistance welding. Quite a few results have been reported in the resistance welding literature, indicating which dissimilar metals can be successfully spot welded and diagrams have been prepared showing graphically these results. No extensive tests have been made, however, correlating metallurgical and tensile properties of resistance welds produced with dissimilar materials. As a matter of fact, in many cases, strength probably was not very important, and as long as the materials stuck together fairly well, the weld was considered satisfactory.

In making resistance welding a reliable means of assembly, much more consideration must be given to the quality in welding dissimilar metals. It is quite obvious that by welding two materials which have entirely different metallurgical characteristics, and which also have entirely different resistance welding characteristics, a large number of problems are encountered which require serious study.

In resistance welding of dissimilar metals, alloy formations by direct melting or by diffusion of two dissimilar metals may produce new metallurgical phase such as eutectics, solid solutions or inter-metallic compounds. A great deal of research work is needed to shed light on this multitude of problems because the number of combinations that are possible go into quite a few hundred. When welding dissimilar metals, the selection of the electrode material plays an outstanding part in order to obtain the necessary quality of the weld.

While in some cases the same type of electrode material and electrode designs may be used against the dissimilar metals, it will be desirable in other combinations to use electrode materials of different chemical composition, different electrical and physical properties and different design in order to obtain the best possible welds.

Until considerably more experimental data are available, it is hardly worth while to discuss the theoretical aspects, and therefore the results given in this paper do not represent a complete analysis, but rather a preliminary investigation which offers some facts obtained under certain experimental conditions.

EXPERIMENTAL SPOT WELDING SET-UP

For the experiments, a welder having a normal rating of 100 kva., was used. The mechanical operation of this welder is controlled by a $^3/_4$ horsepower motor. The welding pressure exerted on the electrodes is obtained by air pressure in a cylinder head above the upper movable slide of the machine and is capable of being adjusted accurately over a wide range of pressures. The slide which is moved up and down by the movement of a toggle and eccentric has a piston attached to its top, which moves up and down to the pressure chamber. The air line entering the welder is broken up into two lines; one running into the top of the piston head, exerting the pressure downward on the electrodes, and a second one running into the bottom of the pressure chamber, exerting its pressure on the bottom of the piston and acting as a counter-balance pressure, compensating for the weight of the moving parts and tension of the current carrying springs.

By adjusting the upper and lower air pressures, it is possible to obtain low and rather adjustable welding pressures.

The current timing control was obtained with an electronic timer permitting accurate and synchronous timing from 1–14 cycles, based on a 60-cycle current wave. A special attachment for the positive identification of conditions during the welding cycle, consisted of a cycle recorder connected in such a fashion as to record the complete pressure and current timing relations.

In spot welding, it is necessary to locate properly the current cycle within the pressure cycle. The relative spacing of these two cycles with respect to time can be identified by the following terms:

1. *Delay* (the time period at which the pressure is on the work before the current is applied).
2. *Welding time* (the period of time in which the current flows).
3. *Hold time* (the period of time during which the pressure remains applied after the current cycle).
4. *Off time* (period of time during which neither the current nor the pressure are applied).

The welding timing conditions used in the present investigation were as follows:

Table 1

Delay	10 cycles
Welding time	variable
Hold time	15 cycles
Off time	20 cycles

THE PREPARATION OF MATERIALS

Before welding, the materials of the present investigation—that is, stainless steel and brass, were buffed on both sides, using steel wool.

This preparation is particularly important in the case of the stainless steel and it was found in preliminary tests that the buffing operation resulted in welds of increased strength and consistency.

* Presented before Dec. 16, 1938 Meeting, Detroit Section, A. W. S.
† Metallurgical Consultant, ‡ Division Engineer, ** Electrical Engineer, P. R. Mallory & Co., Inc., Indianapolis.

ELECTRODE MATERIALS

The electrodes used in this experimental study were carefully machined and efficiently water cooled throughout the tests.

Two grades of materials were employed as shown in Table 2 and Table 3:

Table 2

1. Mallory 3 Metal	
Actual hardness of tips	84 Rockwell B
Electrical conductivity	82% I.A.C.S.

Mallory 3 is a heat treatable Copper base alloy.

The inter-relationship of electrode materials to the metals to be selected will be discussed in later sections of this paper.

WELDING OF BRASS TO BRASS

Before attempting to present the results of welding of Brass to Stainless Steel, it is well to consider briefly what happens in the resistance welding of brass to brass and stainless steel to stainless steel.

In Table 4 are listed the physical and chemical properties of the brass that were employed in the present tests. This type of yellow brass is a material very frequently used in present-day metal fabrication.

Table 3

2. Elkonite Grade 10W3	
Actual hardness of inserts	96 Rockwell B
Electrical conductivity	32% I.A.C.S.

This grade of Elkonite is basically Copper-Tungsten.

Table 4

Chemical composition	66% Copper–34% Zinc
Melting range	905–935° C. (1660–1715° F.)
Electrical resistivity	6.28×10^{-6} ohms per cc.
Electrical conductivity	27.5% of I.A.C.S.
Density	8.45 gms./cc.
Thermal conductivity	0.285 cal. cm.³/cm./sec./deg. C.

The Brass used in the tests was half hard sheet 0.040 inch thick.

The resistance welding characteristics of common brass have been studied by other investigators and resistance welding of brass is being carried out on a production scale by many metal fabricators. The material may be satisfactorily welded over a considerable range of conditions. For the material 0.040 inch thick, the following

Fig. 1 – X 35

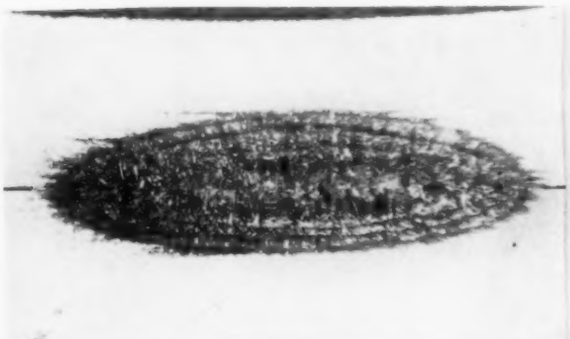


Fig. 3—X 35

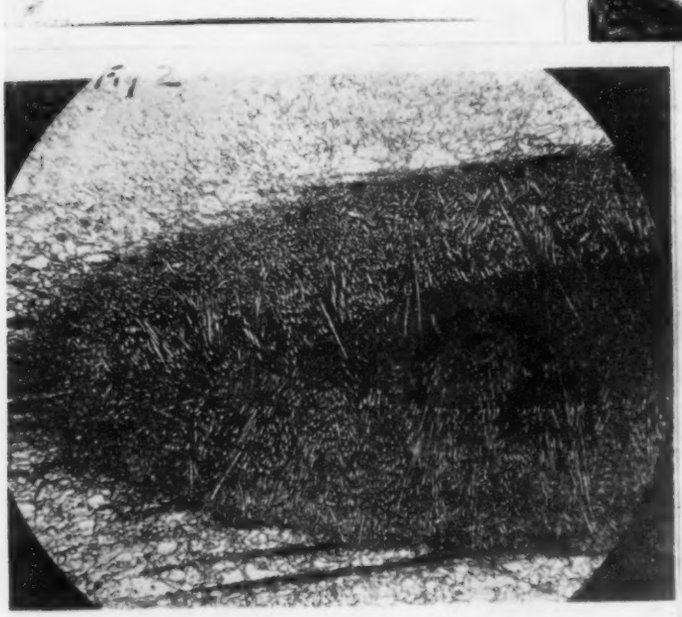


Fig. 2—X 80

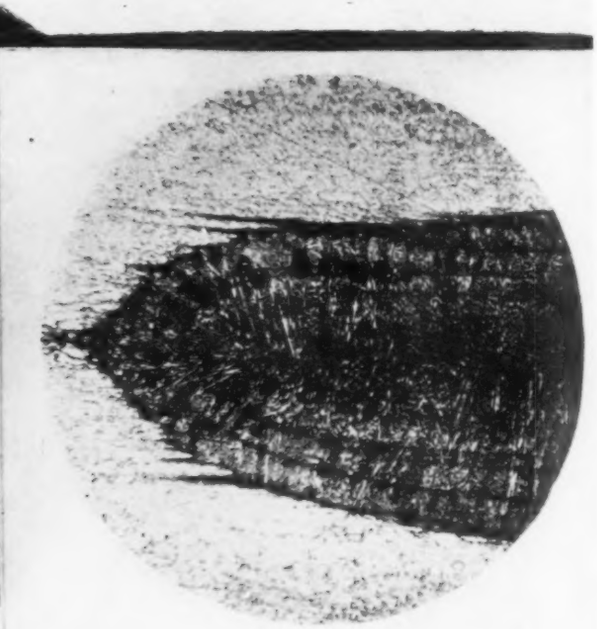


Fig. 3A—X 80

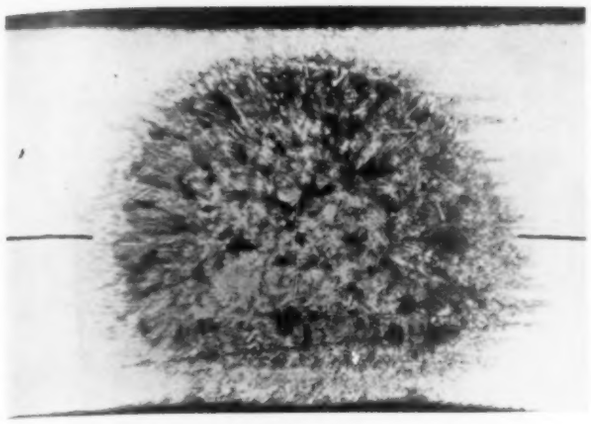


Fig. 4—X 35

range of conditions has been determined by actual tests to be adaptable for obtaining satisfactory spot welds.

Current timing	4 to 10 cycles
Welding pressure	8000 to 14,000 psi
Approximate kva. input necessary, 25–50, depending upon spot dimensions	

With shorter current timing than 4 cycles, it has been found necessary to use higher pressures in order to eliminate sticking of the electrodes, instantaneous melting of the brass at the interface of the electrode and sheet and squirting out of molten brass.

The current values are necessarily very high with short timing. On the other hand, if the current timing exceeds 10 cycles, difficulties are encountered with sticking of electrode points, particularly when Copper base alloy welding electrodes are used. This is due to the fact that with an excessive current dwell, the heat in the brass is allowed to spread to the outer surfaces of the sheet which are in contact with the electrode points and which reach a temperature high enough to cause alloying with the electrode material. The pressure range recommended for welding of brass which was given above, is in general applicable to electrodes where the contacting areas of the welding face range from 0.013–0.08 square inches.

The pressure must be maintained high enough to avoid blow-holes in the weld area. Due to instantaneous heating, the boiling point of Zinc in these areas may be exceeded because Zinc has the comparatively low boiling point of about 905° C.

The following photomicrographs show satisfactory welds in brass sheets of 0.040 inch thickness.

Figure 1 shows a weld which was made with Mallory 3 welding electrodes with a $^1/_2$-inch radius face. The welding conditions were as follows:

Current timing	6 cycles
Total pressure	550 lb.
Approximate kva. input	45

The type of brass used for the present experiment formed a so-called alpha solid solution. In this 66–34 alloy, the second solid solution, which is called "beta," is usually not found, except in the cast condition, or in exceptional cases of severe over-heating. In resistance welding, both of these latter conditions may occur; namely, severe over-heating and actual fusion. In order to remove the beta constituent, it would be necessary to use an annealing treatment. The spot shown in Fig. 1 indicates that the thickness of the spot is approximately $^1/_2$ of the total thickness of the two sheets to be welded together. Such a ratio is satisfactory and will result in comparatively low metal pick up by the electrodes, because there is a sufficiently wide area retained in the brass sheet which has not reached a temperature high enough to cause recrystallization. At the same time, the dimensions of the spot are such that good tensile properties can be expected.

In Fig. 2, the same weld is shown as that in Fig. 1, except at a higher magnification, namely, 80 diameters. The structure is very definitely columnar in its nature and it appears that part of the area has been heated to a temperature range between the solidus and liquidus curve, resulting in the formation of dendrites cooling down from such a semi-liquid state, the dendrites in such case having a definite preferred orientation in the direction of the heat flow.

Figures 3 and 3*A* show a weld made under similar conditions as the welds shown in Figs. 1 and 2, with the exception that tips were used having a 1-inch radius welding face The actual welding conditions were as follows:

Current timing	6 cycles
Total pressure	610 lb.
Approximate kva. input	48

The size of the spot with the larger radius face electrode is considerably greater than the one with the $^1/_2$-inch radius face electrode. This is particularly noticeable in the thickness of the spot. The recrystallized area is closer to the surface of the sheet, indicating that the outside of the sheet was at a higher heat than in the previous case. This will tend to result in a higher metal pick up by the electrode. The type of spot as shown in this figure, however, will give very satisfactory results as far as physical properties are concerned.

Figure 4 shows a weld made with a welding electrode having a welding face of 1-inch radius, the electrode material in this case being Elkonite Grade 10W3. The conditions for welding were as follows:

Current timing	6 cycles
Welding pressure	600 lb.
Approximate kva. input	30

It is interesting to note that it was necessary to decrease the kva. input from approximately 45–48 kva. to 30 kva. with this electrode material of lower electrical conductivity in order to obtain a satisfactory weld.

The type of spot which is obtained with this kind and design of an electrode is altogether different than with

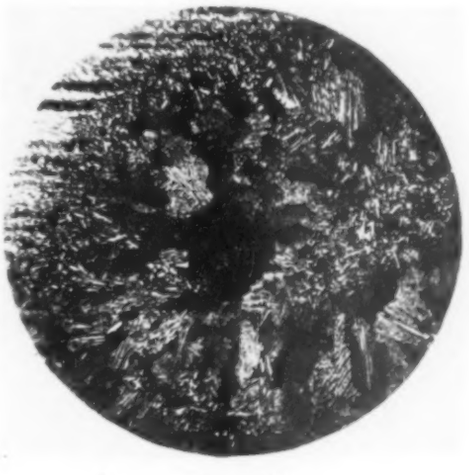
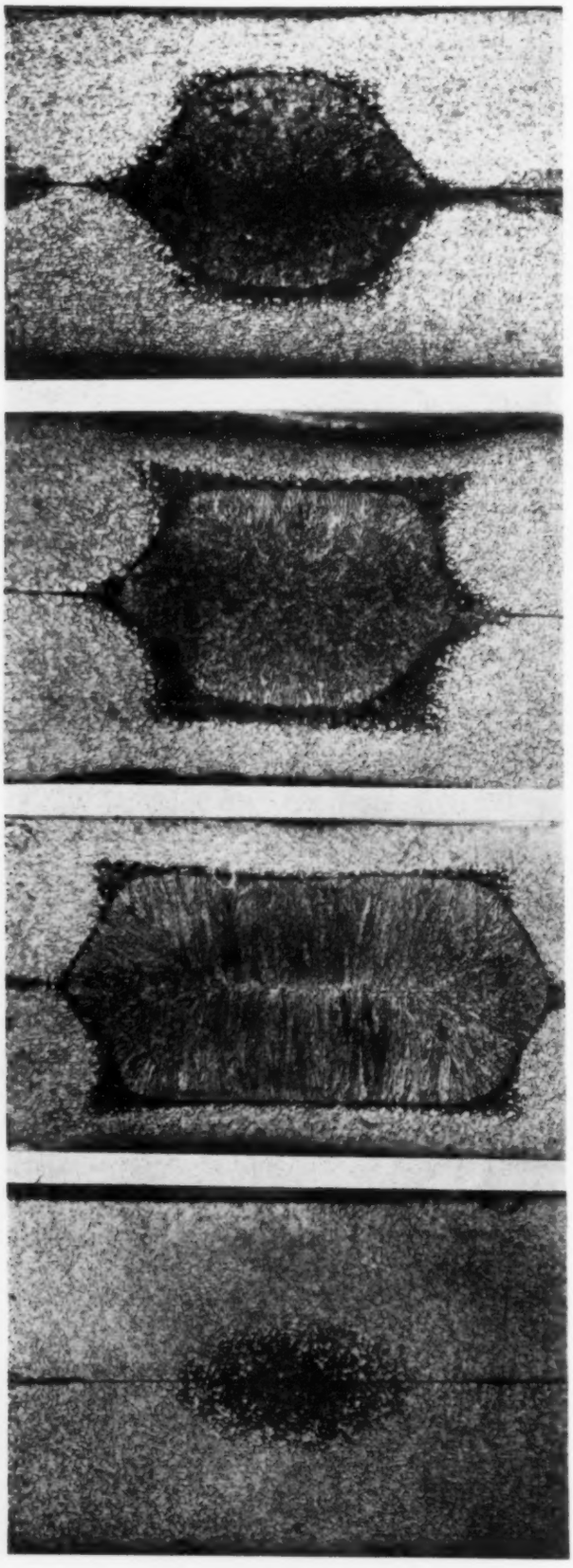


Fig. 5—X 80



Figs. 6 and 7 (Upper Two) X 30
Figs. 8 and 9 (Lower Two) X 30

the Copper base electrodes. In other words, the ratio of width to thickness of the spot weld has changed, the width being decreased while the thickness was increased, resulting in a sphere-like spot rather than an elliptical spot. A possible explanation for this may be the following:

With dome shaped Copper base welding electrodes, the current density will be fairly evenly distributed over the contacting area. In the case of Elkonite, which has not only a higher specific resistance, but due to its chemical composition, will also create a higher contact resistance, the highest current density is concentrated in the center of the dome are, resulting therefore, in a more or less sphere shaped spot weld. In Fig. 5, the same weld as in Fig. 4 is shown at a magnification of eighty times. It should be noted that this weld shows a very pronounced dendritic appearance, indicating that partial melting has occurred during the process of resistance welding. It should further be noted that the weld area shows in the center, and at random orientation of dendritic crystals, surrounded by a band of columnar crystals orientated in the direction of heat flow. The above brass welds could be made without difficulties of electrode sticking or actual alloying. The copper alloy electrodes however, became covered with a very thin film of brass which did not interfere with the performance of these electrodes. The same was found to be true for the Elkonite type electrodes, because as was evident from Figs. 4 and 5, the heat penetrates closely to the surface of the brass sheets to be welded and the immediate welding faces of the Elkonite electrodes tend to run hotter than in the case of the high conductivity copper base electrodes.

The above discussion points to the importance of using the most efficient water cooling of the electrodes.

In order to test the physical properties of the welds illustrated above, shear tests in tension were performed which gave the following results:

Weld	Shear Strength in Tension
Figs. 1 and 2	550 lb. per spot
Fig. 3	610 lb. per spot
Figs. 4 and 5	400 lb. per spot

Further tests are in progress now to determine the tip designs of Elkonite type tips in order to obtain elliptical spots similar to the ones obtained with copper base electrodes. It is to be expected that a tip with a welding face with a larger radius than 1 inch will produce more satisfactory results in so far as it should materially reduce the alloying action with the Brass, the tendency to pick up metal and therefore the number of tip dressings required.

WELDING STAINLESS STEEL TO STAINLESS STEEL

In the following table No. 7, are listed some of the more important chemical and physical properties of the stainless steel used in this investigation.

Table 7

a.	Chemical composition	18 Chromium, 8 Nickel, bal. Iron
b.	Melting point	1450° C. (2642° F.)
c.	Electrical resistivity	70×10^{-6} ohms/cc.
d.	Electrical conductivity	2.5% of I.A.C.S.
e.	Density	7.97 gms./cc.
f	Thermal conductivity	0.04 cal./cm.²/cm./sec./deg. C.

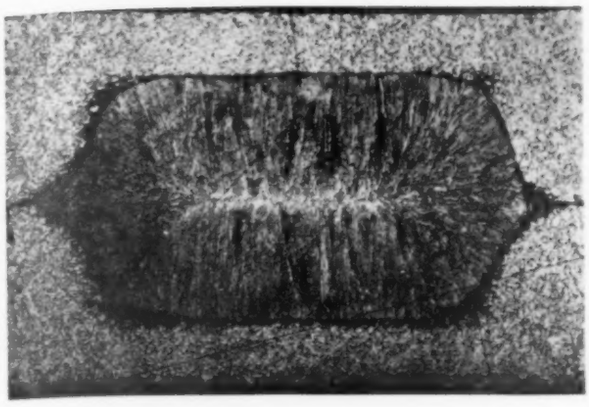


Fig. 10—X 30

The steel was in the cold-rolled condition and was 0.040 inch thick. Due to the high electrical resistivity of the 18-8 steel, the spot-welding characteristics are excellent. The methods and conditions for spot welding have been very well covered by previous investigations. In order to determine the general effects of pressure, kva. input and timing, a number of more or less cursory tests were conducted, the results of which are shown in Figs. 6–10. The effect of increased pressure on the spot dimensions is indicated by Figs. 6, 7 and 8. The pressure in Fig. 6 was 15,000 psi, in Fig. 7, 35,000 psi and in Fig. 8, 40,000 psi. The other welding conditions were as follows:

Timing	2 cycles
Kva. input	16

The photomicrographs are at a 30 times magnification. In running these tests, the current timing was checked by means of a cycle recorder. The amplitude of the wave drawn by the cycle recorder, gives a rough indication of the kva. in the weld. It was noted that the amplitude of the wave, when the weld was made using 15,000 psi pressure, was much less than the amplitude of the wave of the weld made with 40,000 psi pressure. This indicates that even though the transformer setting was the same in both cases, the actual kva. at the weld was considerably different as a result of the difference in pressure. The effect of kva. input on the spot dimensions is shown in Figs. 9 and 10. In Fig. 9, 13 kva. were used, while in Fig. 10, 17 kva. were used. The timing was the same in both cases, namely, 2 cycles and the pressure was 25,000 psi.

The range of welding conditions most widely recommended and which has been confirmed by actual tests, are given below:

Current timing	2 to 10 cycles
Welding pressure	15,000 to 40,000 psi
Approximate kva. input necessary	16 to 25 kva.

These conditions are satisfactory for materials of thickness somewhat similar to that used in our tests

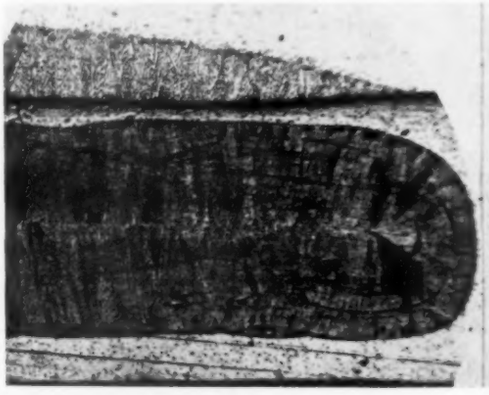


Fig. 11—X 80

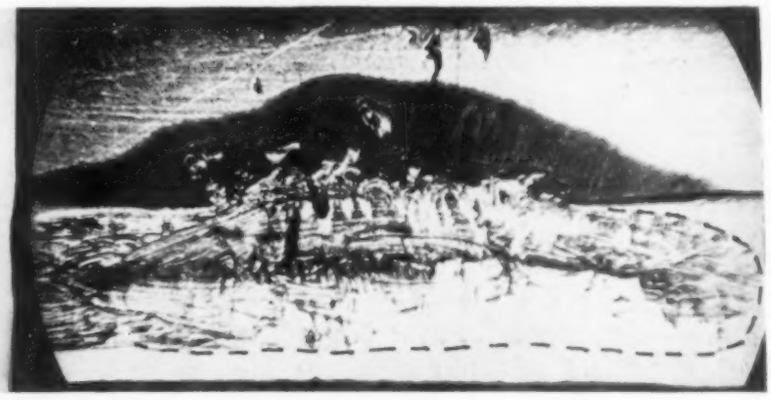


Fig. 13—X 35

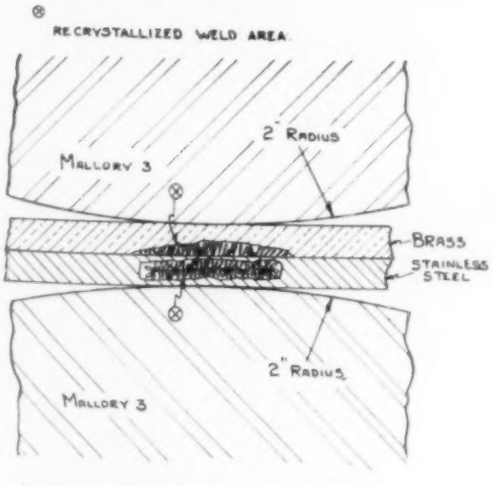


Fig. 12

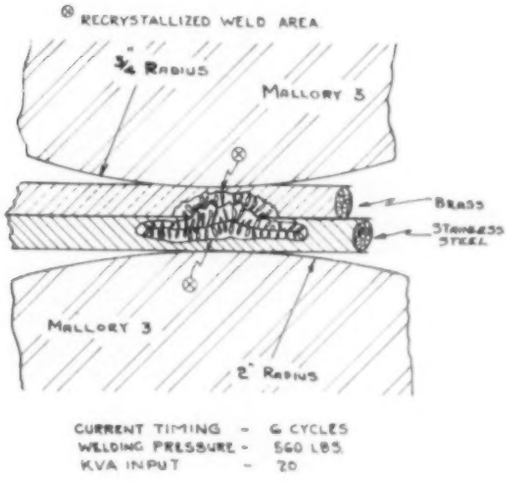


Fig. 14

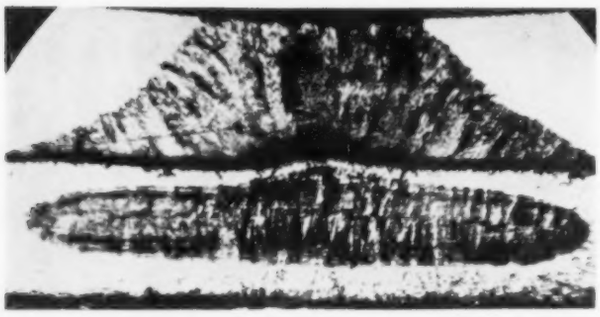


Fig. 15—X 35

and are adaptable to electrodes with a contacting area of the welding face, of 0.013 to 0.08 square inches.

SPOT WELDING OF STAINLESS STEEL TO BRASS

From the previous parts of this paper, the general difficulties connected with the problem of welding stainless steel to brass can be visualized. The two materials are very widely different in almost every respect. Let us consider first the dissimilarity that exists as far as specific resistance is concerned. In resistance welding, the amount of heat generated depends primarily upon the current flowing through the pieces to be welded and the resistance. The latter usually consists of the following 3 parts:

The resistance between the two sheets to be welded.
The specific resistance of the sheets.
The resistance between the electrodes and the work.

If similar metals are used in spot welding, then the highest resistance is set-up between the interfaces of the two sheets to be welded, provided that the right welding conditions are used. In the case of welding two dissimilar metals, such as stainless steel to brass, the maximum resistance may not exist between the interfaces of the two sheets, but may actually be located within the stainless steel sheet, due to its very much higher specific resistance, as compared to that of the brass sheet. The actual heat which is created in the stainless steel and in the brass will be proportionate to the specific resistance of the two materials. Furthermore, it must be taken into consideration, that due to the low specific thermal resistance of brass, the losses in brass will be higher on account of heat being conducted away to the cooler parts much more rapidly. The specific resistance of the brass and the stainless steel at elevated temperatures, can be calculated by taking into consideration the temperature coefficient of resistivity, which, for practical purposes, is approximately the same for the two metals.

The conditions which actually may occur during welding are best illustrated by a number of drawings and a set of photomicrographs, which show the results of our experiments.

In Figs. 11 and 12, are shown the results of using two copper alloy welding tips, the electrodes being of similar design with a welding face of a two-inch radius. This experiment was made, using 560 lb. total pressure, 6 cycles current timing and 22 kva. input.

It should be noted that the columnar structure has been formed in the stainless steel very much the same as if the stainless steel had been clamped alone between the two high conductivity electrodes. In other words, it appears as if the brass of relatively low specific resistance has acted as a continuation of the Mallory 3 welding electrode. There exists a very small section in which the original structure of the stainless steel has not been destroyed immediately adjacent to the brass. It was found that in the regions in which the structure of the stainless steel was not affected by the welding heat, intercrystalline cracks had formed. These cracks were noted both on the side where the stainless steel was in contact with the welding electrode and with the brass. In this connection, it might be considered that if stainless steel is heated to a critical range of 900–1500° F., the tensile strength decreases materially, carbides are precipitated and the material is in general in a very weak condition. It should also be noted that a columnar structure was formed in the brass adjacent to the steel. This type of recrystallization was caused by the application of heat and pressure, the heat originating partly from conduction from the stainless steel, partly from the heat created by the resistance of the interface of the brass and steel sheet and partly by the specific resistance of the brass itself.

The columnar area in the brass has the shape of $^1/_2$ of a typical elliptical spot between two sheets of similar materials.

In testing the strength of this experimental weld, it was found that the brass had stuck slightly to the stainless steel; however, with very little stressing, the two welded sheets fell apart.

In the following two figures, 13 and 14, the results of experiments are shown in which an attempt was made to create a higher current density in the brass by using an electrode of Mallory 3, having a welding face with a $^3/_4$-inch radius against the brass and a Mallory 3 electrode with a welding face of 2-inch radius against the stainless steel. This resulted in a condition in which the stainless steel is pushed into the brass, forming keys and possibly also forming certain new constituents by alloying of the copper base material with the iron base metal. The center line of the spot is still within the stainless steel, and the pressure applied during the welding operation has caused the stainless steel to be forced into the hottest zone of the brass which, at the high temperature, should be quite plastic. By looking at the finished weld, however, this replacement of metal is hard to understand, because there seems to be comparatively little brinelling on either the brass or stainless steel sheet where they are in contact with the welding electrodes.

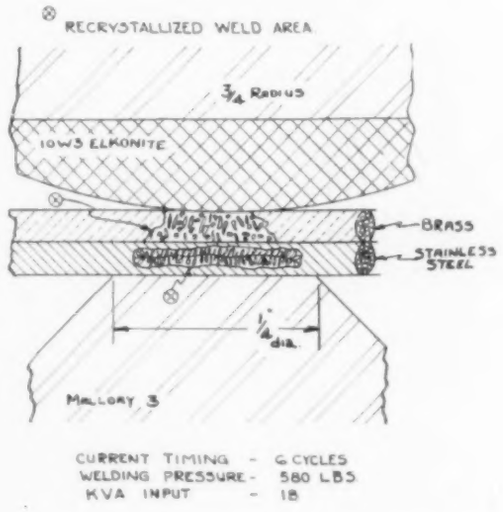


Fig. 16

In spot welding of two dissimilar metals, also the expansion and bimetal characteristics have to be taken into consideration. In the case of brass and stainless steel, the coefficient of expansion is approximately equal, and therefore stresses, due to differences in thermal expansion, should actually be low. The photomicrograph of Fig. 13, shows also a formation of elliptical bands in the spot in the stainless steel, brought out by continuous repolishing and re-etching. Other investigators found that this banding was not observed in welds made with just sufficient energy. They state that "when banding is exhibited, the columnar structure is always more pronounced near the center of the weld where the metal has solidified more slowly."

It might be pointed out here that the etching of these samples was connected with certain difficulties, because the etching characteristics of brass and stainless steel are altogether different.

The general etching procedure, which was used, was as follows: The stainless steel was etched electrolytically, using a solution of 10 grams of oxalic acid to 100 cc. of water. Afterward, the brass was etched with a 50-50 solution of ammonium hydroxide and hydrogen peroxide. This latter treatment not only etches the brass but also cleans up the stainless steel. In Figs. 15 and 16, the results of an experiment are shown, using a 10W3 Elkonite tip with a welding face of $^3/_4$-inch radius against the brass and a flat tip of Mallory 3 having an electrode face of a $^1/_4$-inch diameter against the stainless steel. The weld was made at 6 cycles with 580 lb. total pressure and 18 kva. The object of this tip arrangement was an attempt to distribute the thermal effects more uniformly at the weld interfaces and equalize the current density somewhat with respect to the resistivity of the two dissimilar metals—in short, reduce the current density in the stainless steel and increase the density in the brass. The results were not exactly what was expected. The spot is still localized in the stainless steel, forming a columnar type of weld area, surrounded completely by an area showing the unaffected structure of the rolled stainless steel sheet. Again it was noticed that the stainless steel directly adjacent to the brass was cracked. Attention should be called to the cone shaped columnar structure in the brass, extending all the way out to the outer surface of the brass sheet. The reason for the pronounced recrystallized zone in the brass must be sought in the higher contact resistance which is created between the 10W3 Elkonite electrode and the sheet and also the lower electrical and thermal conductivity of the Elkonite material, as compared with Mallory 3.

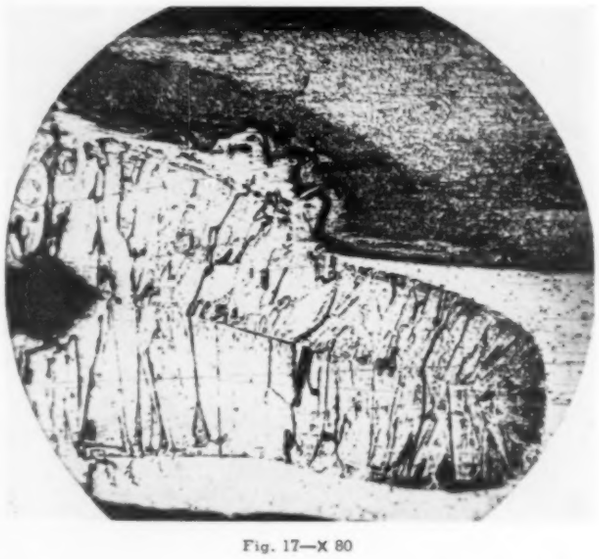


Fig. 17—X 80

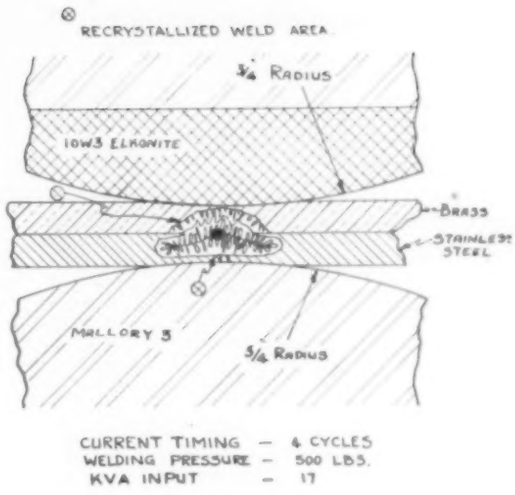


Fig. 18

In Figs. 17 and 18, an experiment is shown in which a weld was made under the same conditions as given for Figs. 15 and 16, except that a Mallory 3 tip having a $^3/_4$-inch radius on the welding face was used instead of a tip with a $^1/_4$-inch flat. In this test, the 10W3 Elkonite tip with a $^3/_4$-inch radius was against the brass and the $^3/_4$-inch radius Mallory 3 tip was against the stainless steel. In the photomicrograph, Fig. 17, the recrystallized zone in the stainless steel extends a considerable depth into the brass, producing a definite keying action in the brass and possibly being alloyed to some extent. Cracks were observed in the stainless steel near the electrode and also in the protrusion of the stainless steel into the brass. Also, it was found that a relatively large hole was formed in the center of the recrystallized zone where the columnar crystals meet each other. This plane is a definite plane of weakness, with low physical properties, particularly at elevated temperatures. The pressure applied during the welding process was apparently high enough to cause cracking, this phenomenon possibly being accentuated by carbide precipitation. Although photomicrographs indicate there are definite weaknesses in a weld of this type, the tensile strength in shear was found to be 480 lb. per spot. The incipient cracks which were found will have less effect on the shear strength than they will have on such properties as impact strength and particularly fatigue strength. The welding conditions pertaining to the spot weld shown in Figs. 17 and 18, were as follows:

Current timing	4 cycles
Pressure	500 lb.
Kva. input	17

In Fig. 19 are shown the results of an experiment in which the welding conditions were similar to those described in Figs. 17 and 18, except that the total pressure was increased from 500 lb. to 650 lb. in an endeavor to eliminate the center hole in the stainless steel that was formed in the previous weld. The electrode materials and tip design remained the same. The increased pressure apparently has reversed the tendency to form a protrusion of the stainless steel into the brass. In addition, actual melting has occurred in the stainless steel at the interface, causing particles of the stainless steel to be

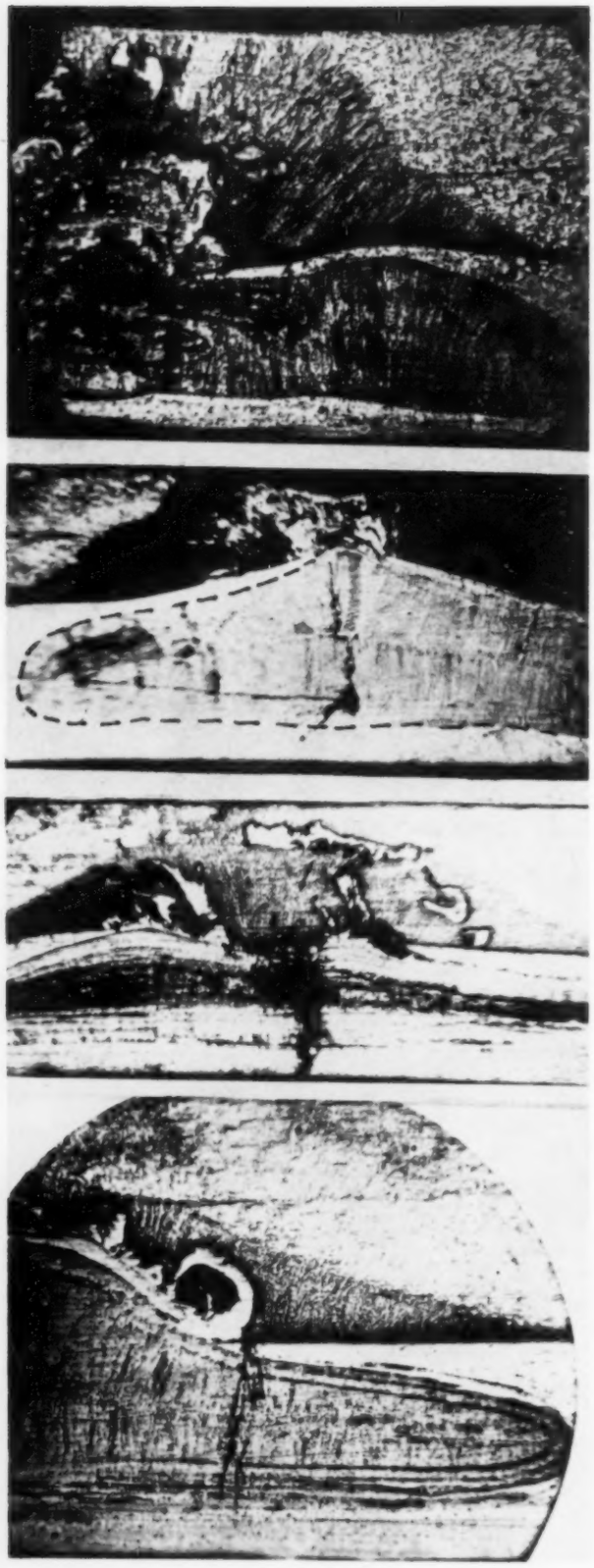


Fig. 19 (Upper) X 80

Figs. 20 and 21 (Center) X 35

Figs. 22 (Lower) X 80

forcibly ejected into the brass. Of interest, too, is the fact that the recrystallized zone in the brass sheet extends throughout the entire thickness of the latter. There was also a pronounced brinelling effect caused by the high pressures in both the brass sheet and the stainless steel sheet. No sticking of the 10W3 electrodes was encountered, despite the high temperature at the electrode face. The strength of this weld was unsatisfactory. When the weld was tested to destruction, only a small slug was pulled from the stainless steel side of the weld. This slug was irregular in shape and had the appearance of small trees. The fracturing occurred instantaneously with no tearing or deformation, indicating a very brittle weld, the brittleness occurring in the stainless steel.

In Fig. 20 are shown the results of an experiment in which the conditions were similar to those described in Figs. 17 and 18, except the current timing was increased from four to seven cycles. Here again, the electrode materials and tip design were the same. Under these conditions, a very poor weld was obtained. A large crack extended through the thickness of the weld area in the stainless steel, resulting in very low and undesirable physical properties of this particular weld.

In Fig. 21, are shown the results of an experiment in which a 10W3 Elkonite tip, having a $^1/_2$ inch diameter flat welding face, was used against the brass and a 2 inch diameter radius Mallory 3 tip against the stainless steel. The current timing was 4 cycles, the total pressure 650 lb. and the kva. input approximately 18. Here again, cracking occurred in the stainless steel, extending throughout the thickness of the sheet. Several large particles of stainless steel were found to have been imbedded deep in the brass sheet.

In Fig. 22 are shown the results of an experiment in which a 2-inch radius Mallory 3 tip was used against the brass and a $^1/_2$ inch diameter flat Mallory 3 tip against the stainless steel. This arrangement was used in an endeavor to increase the current density in the brass. The photomicrographs indicate a relatively good bonding of the stainless steel protrusion in the brass sheet. The high conductivity copper base electrode against the brass has transmitted the heat rapidly away from the brass sheet, thereby retaining the original cold-rolled structure of the sheet and limiting the size of the recrystallized zone in the brass.

There still seems to be considerable cracking in the stainless steel. The shear strength in tension of this weld was 472 lb. per spot.

SUMMARY

It is hardly necessary to point out that the present investigation is by no means conclusive. The investigation, however, has revealed the considerable difficulties that exist in welding two dissimilar metals, such as stainless steel and brass, and points to the importance of additional research along similar lines. One point which has been very forcibly brought out, is the correct choice, not only of the electrode material, but also of the electrode design in combination with suitable welding conditions. As far as the investigation has gone, one can probably say that it is possible to attach brass to stainless steel, and obtain a reasonable strength of such a weld; however, the type of weld is altogether different from the conventional resistance weld, obtained in welding similar metals, such as low carbon steel to low carbon steel. There, the phenomenon is definitely a recrystallization process in which crystals grow across the interfaces of the two sheets to be welded, under the influence of pressure and temperature. In the present case, the phenomenon is much more complicated, because actual fusion does occur both in the stainless steel and in the brass sheet. In the specific case of welding brass to stainless steel, there are

other possibilities besides further developments in welding technique which might help to provide a solution. Experiments have been made, for instance, by some brass manufacturers, to produce a brass which has a high specific resistance.

Another possibility is to use a special grade of stainless steel in which carbide precipitation and embrittlement are materially reduced by the addition of such elements as Titanium, Columbium, etc. These additions should tend to retain the ductility of the stainless steel at temperatures which are encountered in spot welding, and should eliminate the cracking of the stainless steel sheets, observed in the results reported. At the same time, the corrosion resistance should remain high.

A number of experiments which were carried out in our laboratory also indicated that possibilities exist to use a liquid flux coating between the two dissimilar metals in order to improve the strength of the welds.

Welding General Hospital Building, Boston*

By J. THEODORE WHITNEY†

THE George Robert White Memorial Building is in the center of the group of buildings known as the Massachusetts General Hospital. In the buildings which surround this building are over one thousand sick patients, many of whom require absolute quiet for recovery.

The noise that results from riveting or reaming for turned bolts was considered by the hospital authorities to be a serious matter and as a result they requested that the structure be field welded. The application for the permit was made and the Architects of the building, Messrs. Coolidge, Shepley, Bulfinch and Abbott, requested approval of field welding of the structural steel.

Due to the fact that Boston is still operating under the old obsolete law which does not cover welding, and inasmuch as the new law passed through by the Legislature had not been signed by the Mayor and Council, and therefore could not be followed, it was necessary to go to the Board of Appeal for permission to weld. This permission was granted with the proviso that J. Theodore Whitney assume entire charge of the welding in all its aspects, that he file an affidavit to cover the welding and make a final affidavit when the work was completed. Also that he should have a qualified inspector at the building when welding was in progress and that only welders approved by the Department should be used.

The New England Structural Company of Everett, Massachusetts, made the welding details which were subject to approval of the Welding Engineer, and also fabricated the steel framing. The Scott Welding Company of Brooklyn, New York, was the welding contractor. Mr. Anthony S. Coombs, a member of The Whitney Engineering Company (of which Mr. Whitney, the Welding Engineer, is President) was also identified with the welding of the Boston Edison Building on Tremont Street and the Pediatric Building of the Boston City Hospital, and served as Inspector for welding at this building. The Sawyer Construction Company of Boston was the General Contractor.

The welders were all steel workers and each was required to pass a test to show proficiency in welding unless a recent test had been made and the man had recently engaged in welding. These tests were made in a flat, vertical and overhead position with the requirements for qualification of a tensile strength of not less than 100,000 lb. on the 6 inches of $^3/_8$-inch weld on a test specimen, that regardless of the strength of the test the weld should show no porosity, lack of penetration or slag inclusion. Many of these tests broke between 120,000 and 130,200 lb. These tests were made at the laboratories of the Massachusetts Institute of Technology.

The building is of the tower type and covers about 28,000 square feet on the ground, gradually changing in plan to a T shape at the 5th floor level. The building then assumes a cruciform plan for six stories and then changes into a tower for the remainder of the building. The basement floor which is the first framed level is at 13 feet 1 inch Boston base and the roof of the tower, the eighteenth framed level, is at grade 219 feet. Two hundred sixteen feet from basement floor to roof. The tonnage of steel used in the structural frame amounted to 2274 tons. Except for fifteen inches of welding which was done by a gasoline driven generator, all welding was done by electric driven generators. The foreman representing the welding company laid out the lengths and designated the sizes of all welds in accordance with the welding details and the inspector checked these lengths and sizes as well as the actual condition of the welding. The number of welders engaged totaled twelve, not including the foreman who did some welding when opportunity permitted. Eight welders were used for considerable period but in general five constituted the average number.

Massachusetts General Hospital

WELDING STARTED: August 16, 1938
WELDING FINISHED: November 22, 1938

1.	Height basement floor to roof (18 levels)	206 feet
2.	Total tonnage in building	2274 tons
3.	Number of inches of welding (all sizes)	115,238
4.	Equivalent $^5/_{16}$ths weld	129.516 inches
5.	Equivalent $^3/_8$ths weld	89,925 inches
6.	Number of inches of weld (all sizes) per ton	50.68 inches
7.	Number of inches of $^5/_{16}$ths equivalent per ton	56.95 inches
8.	Number of inches of $^3/_8$ths equivalent per ton	39.54
9.	Number of inches of weld (all sizes) done by foreman:	3074
10.	Number of inches (all sizes) done by welders	112,164
11.	Number of hours of welders' time	2060
12.	Inches per hour of welders' time	54.4
13.	Feet per day welders' time	36.26
14.	Total helpers' time	580 hours
15.	Number of inches per hour of helpers' time	198.7
16.	Number of hours hoisting engineer's time (Union requirement for machine attendants)	842 hours
17.	Number of inches of weld per hour of hoisting engineer's time:	136.86
18.	Number of hours of foreman	592
19.	Number of inches (all sizes entire job) per hour of foreman's time	194.7
20.	Electrode used $^5/_{32}$-inch wire 500 lb. $^3/_{16}$-inch wire 4900 lb. Total	5400 lb.
21.	Weld, per lb. of electrode wire bought	21.34 inch
22.	Inches of weld per lb. of electrode melted	30.49 inch
23.	Amount of electrode melted (Assume waste as 30%: 1620 lb.)	3780 lb.
	Pounds of electrode melted per ton of steel	$1^3/_4$ds
24.	Number of K.W.H. electricity used	13,754
25.	Number of K.W.H. used per ton of steel	6.05
26.	Number of K.W.H. used per lb. of electrode melted	3.63
27.	Number of lb. of electrode melted by 1 K.W.H.	0.274 lb.

* Presented before Joint Meeting, Boston, Society of Civil Engineers and Boston Section AMERICAN WELDING SOCIETY, at Lynn, Mass., Dec 21, 1938.
† President, The Whitney Engineering Company, Boston.

The welding followed closely behind the erection and there were several instances where the welders had to lay off until steel could be erected.

The contractor elected to remove the erection bolts which is not usually done.

The welding on this particular building again confirmed previous observations regarding welding, namely —speedier erection, stiffer frame, less scaffolding needed than for riveting, reduced fire hazard because there are no hot rivets to drop, decreased accident hazard because there are no hot rivets to pass, noise practically eliminated, and greater ease in rectifying shop errors or in making changes required after the steel is erected.

Scepticism regarding welding is due primarily to lack of familiarity with the process. No new set of mathematics is necessary for the computations of loads, stresses or strains. Welding is simply another means of fastening steel together and it seems highly desirable that all facilities and processes should be made available for use under controlled procedure. The term "controlled procedure" should be emphasized.

Furthermore, in these days when economy in construction is needed to make possible more building in order that more taxable property may be had in the community, any new process, tool or material when proved safe and adequate, should be allowed under such regulations as will secure adequate and proper results.

Highway Department Welding Survey

By CLARK A. DUNN*

The data given in the table represents the compilation of the data obtained from the inquiries mailed to each highway department.

Further studies will be made and additional suggestions or information will be welcomed.

* Assoc. Prof., Department of Civil Engineering, Oklahoma A. & M. College.

1. Repair Work
2. Used on Secondary Members
3. Used on Primary Members
4. Hired Operators (Tested)
5. Hired Operators (Not Tested)
6. Employee Operators
7. A.A.S.H.O. Specif.
8. AMER. WELDING Soc. Specif.
9. State Specif.
10. Cost, Data
11. Plans Submitted
12. State Owned Equipment

State	1	2	3	4	5	6	7	8	9	10	11	12	
Alabama	No Answer Received to Date												
Arizona	No Answer Received to Date												
Arkansas		X							X				
California	X	X					X				X		
Colorado		X		X			X		X		X		
Connecticut	X												Welding used in repair work
Delaware	X	X					X	X					Reinforce old structures
Florida													In steel bearing piles
Georgia	X	X					X						
Idaho													No welding
Illinois		X			X			X			X		
Indiana	X	X			X			X		X	X		Evidence of qualification
Iowa	X	X					X	X			X		
Kansas		X		X				X	X		X		Tested welded girder to destruction
Kentucky		X											
Louisiana	No Answer Received to Date												
Maine	X												Little welding—No designs
Maryland		X									X		Remodeled Bridge 11 yrs. ago
Massachusetts		X					X						
Michigan	X	X		X				X					Suggests registration of welders
Minnesota	X	X											
Mississippi	No Answer Received to Date												
Missouri	X							X					
Montana													Welded shoes
Nebraska	No Answer Received to Date												
Nevada		X		X				X					Electric arc welding
New Hampshire		X											Splice steel piling
New Jersey		X											Very little welding
New Mexico							X						Weld plate girders to stringer
New York		X				X						X	Planning design welded structure
North Carolina		X											
North Dakota	No Answer Received to Date												
Ohio		X		X					X		X		Advantages include appearance
Oklahoma	X	X					X			X			Strengthen old I-Beams. Use on shoes on Purcell Bridge
Oregon	X	X		X				X		X	X		Welding on curved underpass
Pennsylvania	X	X		X					X		X		Only electric arc welding
Rhode Island	X	X					X					X	
South Carolina	X								X		X		Widening steel bridges
South Dakota	X												To widen ponies; cut center of floor beam and weld splice
Tennessee	No Answer Received to Date												
Texas	X	X				X		X	X			X	Weld, reinf. and ornamental steel railings
Utah	X						X						Remodeled street-car viaduct for automobile traffic
Vermont	X											X	
Virginia	X	X						X					
Washington	X	X					X						Allow only electric arc weld
West Virginia	X	X		X				X	X				
Wisconsin	X												
Wyoming		X					X				X		Constructing welded flume

Welding Society ACTIVITIES — Related Events

AMERICAN WELDING SOCIETY, ITS SERVICE TO ITS MEMBERS AND TO INDUSTRY

The purpose of any engineering or scientific society, broadly speaking, is cooperation for mutual benefits in those parts of the field which cannot be satisfactorily cultivated either by an individual, by a single corporation or by a group of corporations, usually called a Trade organization.

The activities of the AMERICAN WELDING SOCIETY and the resulting service to its members are well covered in the little pamphlet entitled "Purposes, Activities, Procedure and Membership."

Nevertheless, there is one broad aspect of this service which is often overlooked by both the individual and the corporate members, and it is to this aspect that your attention is now particularly called.

The Place of an Engineering Society

The development of the science and art of any branch of engineering involves the work of individuals and of associations, both professional and industrial. The allocation of credit to the several individuals or associations involved, is absolutely impossible in the quantitative sense, but there can be no doubt as to the very important part played by the Engineering Societies which render a service not rendered by any other type of organization. The benefits of this service accrue directly or indirectly to every individual and to every corporation connected with the corresponding industry. In a broader sense these benefits accrue also to the nation as a whole. For example, any increase in knowledge which makes possible the application on welding in a new field or makes applications in older fields safer as well as more efficient, means more business for both the manufacturer of welding equipment and the manufacturer who uses such equipment, economies for the users of the welded products, more demand for electric power, safer risks for Insurance Companies and more opportunities for employment, not only of welding operators, but also of welding engineers and many others who either are or should be members of the AMERICAN WELDING SOCIETY.

Making the Welding Society Effective

The part which the Society has already played in the development of the science and art of welding and the resulting increase in national efficiency is a very important one, but the magnitude of this service is very largely dependent upon the heartiness of the cooperation and financial support of its members, both individual and corporate. The mere magnitude of the membership is an important factor, since a considerable increase in membership not only increases the spread of the benefits over a larger group, but also makes the JOURNAL more attractive to advertisers, and increases the income of the Society as well as the amount of service which it can render.

In other words each additional member, even though his dues may not pay the cost of the service which he receives, is contributing to the advancement of the art and to the increase in the service rendered by the Society to its members and to industry.

Membership in the Society

All too often it happens that a prospective member, individual or corporate, or a prospective contributor to welding research, looks too closely at what he can see in the way of direct or immediate benefit, on some of which it is often very difficult to put one's finger.

The real questions should be; (1) Are the objectives of the society worthy and important? (2) Is the work of the society aimed in the right direction? (3) Is this work being conducted in a reasonably efficient manner, and are the results commensurate with the available resources? Reasonable answers to these questions are as follows:

1. Neither the need nor the objectives of the society have ever been seriously questioned.

2. Although there has been much discussion of this question in the past, and some differences of opinion, it is now generally agreed by all those thoroughly informed that the answer to this question should be a vigorous "Yes."

3. Any one who knows the history of the AMERICAN WELDING SOCIETY and that of the older Engineering Societies, knows that it has contributed in proportion to its resources vastly more, particularly in the field of codes and research, than any of its older brothers.

Although it would take too much space to enumerate these contributions, one or two significant ones should be mentioned. Achievements in research have so far clarified the understanding and the application of the fundamental principles of safe welding as to largely increase the field of safe application. Moreover, these principles have been embodied in the numerous codes and standards issued by the Society. The appearance in 1931 of the rules for the fusion welding of drums and shells prepared jointly by the AMERICAN WELDING SOCIETY and the A. S. M. E. Boiler Code Committee and incorporated into the Boiler Code, marked a turning point in the industry. Since that time the application of fusion welding in this field has grown with leaps and bounds, until now practically all large drums for boilers and pressure vessels, particularly for high pressure and high temperature service are fabricated by fusion welding. This, together with a considerable number of equally important codes have been issued, or are being formulated by the AMERICAN WELDING SOCIETY. The amount of work involved in revising these codes as the art advances is very great. It is thus no more than fair that the very large number of beneficiaries should share in the financial as well as in the intellectual support of the Society and help to increase its prestige in this important field.

Support Needed

With these questions all answered in the affirmative, it is only reasonable to expect the support of at least a majority of the beneficiaries of the Society activities, since the Society has certainly earned the confidence and support of all of those connected with the welding industry. If it were to receive this support, its membership as well as the service it could render would be enormously increased. It is of course probable, if not inevitable, that there is still a very small minority whose attitude is critical, but as the Society is a democratic organization, it is always possible to get action on constructive criticism which has the approval of the majority of members.

To sum up, it is our hope that a larger number of those actively concerned in the art of welding may drop their short range personal and sometimes critical attitude, recognize the tremendous opportunities for service by the Society, and decide to get into the boat, to help pull, and if possible, to help steer.

NOTICE REGARDING CODE 1—PART A

The current 1937 Edition of the A. W. S. Code for Fusion Welding and Gas Cutting in Building Construction, Part A—Structural Steel, was printed in abstract form in the January 1938 issue of THE WELDING JOURNAL. Since only the changes from the previous edition were printed in full, the abstract should have stated that these changes refer to the 1934 Edition of the Code, which was the one in effect prior to the adoption of the 1937 Edition.

Copies of the Building Code may be obtained from the office of the AMERICAN WELDING SOCIETY at 25 cents each.

THE ENGINEERS' MANUAL

A second edition of the well-known Engineers' Manual by Ralph G. Hudson, has just been published by John Wiley & Sons, Inc., of New York. The price of the book is $2.75. It contains 340 pages of condensed material of use to the engineer. The work originated from the conception that the practicing engineer or engineering student would welcome a consolidation of the formulas and constants for which he is accustomed to search through several volumes and that the application of each formula might be explained more concisely than in texts devoted exclusively to the process of derivation. With this end in view those engineering formulas, mathematical operations and tables of constants which appear to be most useful are presented in systematic order and in a size of book designed to fit the pocket.

Each formula is preceded by a statement in which its application, the symbology of the involved physical quantities and definite units of measurements are indicated.

For the practicing engineer the aim throughout has been to enable him to obtain results quickly and accurately even in a branch of engineering to which he can give little attention.

The second edition also contains revisions and extensions of all tables of physical constants, new steam tables, recomputations of all conversion factors affected by the latest definition of the British Thermal Unit, an enlarged table of conversion factors, and many additions throughout the book.

HANDBOOK FOR WELDED STRUCTURAL STEELWORK

The first edition 1938 of the Handbook for Welded Structural Steelwork has been published by The Institute of Welding, 104 Victoria Street, London, S.W. 1.

This Handbook has been produced to meet the need for a standard book of reference on welded construction, and to provide the technical data necessary for the design of welded structures.

The first part of the Handbook contains tables of properties of standard sections and arrangements commonly used in welding construction. The second part contains calculations and details for typical examples for welded construction.

The preparation of the Handbook was carried out under the direction of the Handbook Committee of the Institute of Welding.

The book contains 220 pages with a number of illustrations, formulas and tables. It is a ready reference book for any one interested in structural welding. Price $1.25.

NEMA TRANSFORMER STANDARDS

The National Electrical Manufacturers Association announces the release of a new Standard entitled "NEMA Specialty Transformer Standards, Publication No. 38-52."

This book is divided into five parts as follows:

Part I—Doorbell Transformer Standards.

Part II—Signalling Transformer Standards.

Part III—High Reactance Control Transformer Standards.

Part IV—General-Purpose Specialty Transformer Standards.

Part V—Luminous Tube Transformer Standards.

Copies of the complete Standard in loose-leaf form or of any of its parts may be obtained from the National Electrical Manufacturers Association, 155 East 44th Street, New York, N. Y. at the following prices: Complete Standard $1.10, Part I $.15, Part II $.25, Part III $.15, Part IV $.75, Part V $.25.

THE PRINCIPLES OF METALLOGRAPHIC LABORATORY PRACTICE

By George L. Kehl*

Here is a book that fills a very definite need for a textbook of fundamental principles involved in metallographic laboratory practice—a book that will bridge the gap between theoretical physical metallurgy and its practical application in the laboratory. The book is not, however, a laboratory manual outlining definite ex-

* Lehigh University.

INDEX TO ADVERTISERS

Air Reduction Sales Co. . . . Outside back cover
American Brass Company 189
American Telephone & Telegraph 179
Anti-Borax Compound Company 188
Bastian-Blessing Company 188
General Electric Co. . . . . Inside front cover
Jackson Electrode Holder Co. 186
Krembs & Company 190
Lincoln Electric Company . . . . Inside back cover
The Linde Air Products Company 136
P. R. Mallory & Co., Inc. 191
The McKay Company 190
Metal & Thermit Corporation 198
National Carbide Corporation 182
Page Steel & Wire Division 183
Safety Equipment Service Co. 184
Shawinigan Products Corp. 192
Stulz-Sickles Co. 194
Thomson-Gibb Electric Welding Company . 192
Union Carbide and Carbon Corp. 136
Victor Equipment Company 181
Westinghouse Elect. & Mfg. Co. 193
Wilson Welder & Metals Co. 185
Wilson Welder & Metals Co. 187
Wooldridge Aluminum Welding Products . 194

Seventy million times a day the public tests the quality of Bell System service. The measure of this service is not only its promptness, reliability and low cost. It is also the courtesy with which it is given.

Our genuine desire is to make the Bell System a friendly and helpful institution . . . and to give you the best, the most and the cheapest telephone service in the world.

BELL TELEPHONE SYSTEM

You are cordially invited to visit the Bell System exhibit at the New York World's Fair

periments and exercises, but is a treatment of principles, both theoretical and applied, that are necessary for a sound understanding of laboratory procedure. 359 pages, price $3.50. Published by McGraw-Hill Book Co.

WELDED PRESSES ARE KEY MACHINES IN PREPARATION OF SCRAP IRON

Huge Presses Crush Car Bodies with Ease

Scrunch! Like eggshells, the stripped skeletons of the gas-eaters of the 20's are crushed into a solid cube scarcely over a cubic foot in size. What was once the pride of the highways quickly and unceremoniously becomes lowly scrap iron—destined for use by the many wildly re-arming nations of the world.

It's quite a business, this preparation of scrap iron—and an industry in which modern electric arc welding has played an important part. For the huge all-welded presses, built in this case by a Milwaukee manufacturer, are the key machines in scrap iron production. Shown above is one of the largest of its kind ever made, developing 400 tons pressure, reducing auto bodies to cubes 20 × 16 × 20 inches in volume.

A Real Manufacturing Problem

The construction of a press capable of withstanding such terrific strain, and high speed production is, of course, an extremely interesting manufacturing problem. Before the rush of new business and the demand for faster manufacturing became so acute, this company ordinarily used heavy castings to make up the greater part of the press. However, as capacity demands became larger, it was deemed more expedient in every way to turn to welded plates rigidly strengthened by welded honeycomb sections. Not only does this welded construction gain the benefits of greater strength with less weight, it is much faster. Also, as the manufacturer says, it has eliminated the troubles formerly met in producing huge castings free from all harmful air bubbles, inclusions and other imperfections which would show up only under the strain of sustained operation.

Naturally, skilled welding is a prime requisite for this job and the manufacturer has an intensive training course through which all welding operators must pass before qualifying for any but the most elementary welding task. Shown in the second photograph, is the welder finishing up on a smaller size press having a capacity of 8 to 12 tons of new material and 5 to 6 tons of old material per hour.

MARYLAND CASUALTY CONFERENCE

Members of the Boiler and Machinery Inspection Division of the Maryland Casualty Company of Baltimore held a three-day conference at the Home Office on January 23rd, 24th and 25th. The meeting was attended by many of the chief boiler inspectors and service directors from various cities.

Mr. Holger Jensen, Manager of the Engineering Division, presided.

Much time was devoted to welding and inspection of welded boilers, pressure vessels and power piping, and such related problems as Boiler Code interpretation and the recent rulings of the A. S. M. E. Boiler Code Committee.

One of the things reported by the field men, which should be of interest to manufacturers and power plant engineers, revolved around a very bad situation in regard to permissible boiler repairs, and repairs and replacement to power piping.

It seems that many plant engineers proceed with these repairs by welding without first notifying the State Boiler Inspector or Insurance Company Inspector, only to find out that the State would not accept the installation because of the lack of concrete evidence that a standard welding procedure was followed. These rejections created many unpleasant situations and expensive delays.

The Maryland Casualty Company has available for free distribution a leaflet—"Requirements for Repairs by Fusion Welding on Boilers and Pressure Vessels," as approved October 24, 1935.

A number of young boiler inspectors who have recently passed National Board examinations will be given welding training by The Maryland in Chicago, Illinois. The first group will start on February 7th. They will be placed after completion of the course in various cities throughout the mid-western territory.

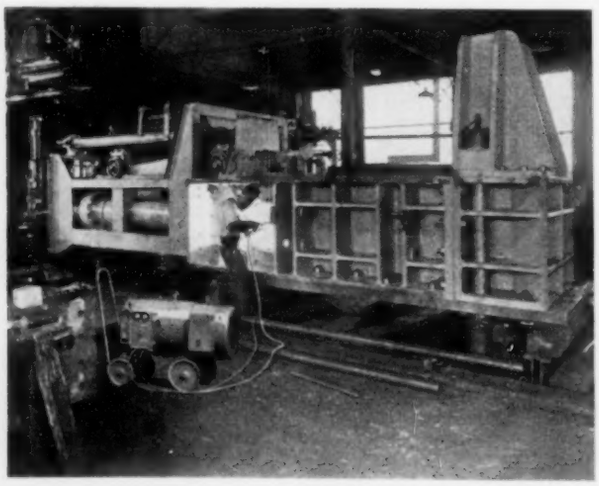
TENTATIVE SPECIFICATIONS FOR SPIRAL WELDED STEEL OR IRON PIPE

The American Society for Testing Materials, 260 South Broad Street, Philadelphia, Pa., has issued specifications on the above subject. A. S. T. M. Designation: A 211-38T. This Tentative Standard of the American Society for Testing Materials is, under its Regulations, subject to annual revision. Suggestions for revision should be addressed to the Society.

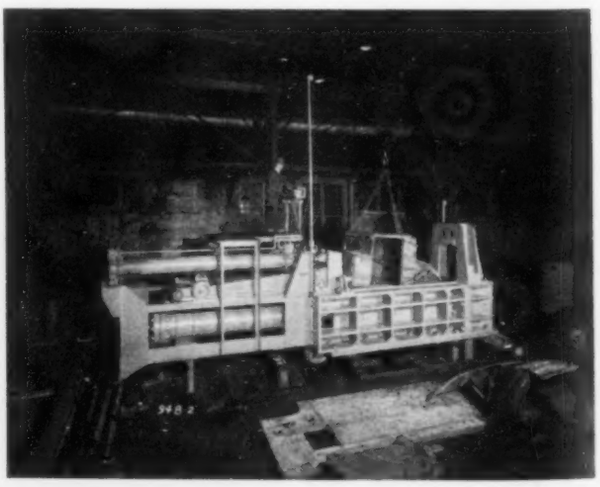
TEMPERATURE SYMPOSIUM

A symposium on "Temperature and Its Measurement in Science and Industry" will be held under the auspices of the American Institute of Physics, probably next Fall, the dates to be announced later. Consistent with the title, the symposium will broadly cover many fields, its primary purposes according to present plans being to (1) coordinate the treatment of the subject in the sciences and branches of engineering, (2) review principles and bring up to date the record of recent work, (3) accumulate contributions for a comprehensive text, to be published as soon as possible after the symposium is held, (4) reveal the subject as an important branch of physics and (5) supply schools with the information required for the improvement of curricula. The Institute confidently expects that a stimulating, valuable and unified program will be arranged, an aim which will require the help of many contributors.

A representative steering committee has been formed consisting of the Chairman, C. O. Fairchild, Director of Research, C. J. Tagliabue Mfg. Co.; Dr. E. F. DuBois, Medical Director Russell Sage Institute of Pathology and Professor of Medicine,



Welding a Car Body Press



Now You See It—a Completely Stripped Auto Body—and Now You Don't. Instead, a Small Block of Metal Hardly Over a Cubic Foot in Size

VICTOR

A GOOD REGULATOR

Saves its purchase price many times over in lowered gas consumption, better torch operation and safety. It is economical to replace worn-out or obsolete equipments with modern apparatus.

VICTOR EQUIPMENT COMPANY

844 Folsom Street
SAN FRANCISCO

3821 Santa Fe Avenue
LOS ANGELES

DISTRIBUTORS IN ALL PRINCIPAL CITIES

Cornell University Medical College; Dr. Gustav Egloff, Director of Research, Universal Oil Products Co.; Dr. John Johnston, Director of Research, U. S. Steel Corporation; Dr. Walter G. Whitman, Head, Department of Chemical Engineering, Massachusetts Institute of Technology; and Dr. H. A. Barton, Director, American Institute of Physics.

Those who are interested in taking part in this symposium should communicate with the Institute at an early date, giving information regarding their field of work and the subject of the contribution they wish to make. Such contributions will be coordinated with the subjects of a group of invited papers, and assignments and divisions made. Further information for contributors will be available shortly. AMERICAN INSTITUTE OF PHYSICS, 175 Fifth Avenue, New York, N. Y.

ARC-WELDED STEEL FRAME IN 12-ROOM RESIDENCE

In contrast with the average type of home which has been constructed in the past with arc-welded steel framing is the imposing residence shown in the accompanying illustrations. (See Cover and Fig. 1.) It has 12 rooms, two sun decks, an elevator and year-round air conditioning. The 96,000-pound steel framework is welded throughout by the shielded-arc process. The home shown is that of Mr. John Wilson, president, Wilson Mfg. Company, Wichita Falls, Texas.

House beams are made from $2 \times 2 \times 1/4$-inch angle top and bottom flange with $1\frac{1}{2} \times 1\frac{1}{2} \times 3/16$-inch lattice, welded in fixture at a speed of one foot of beam per minute. Maximum beam span is 18 ft. Beams are 10 inches deep. Walls have 3-inch channel studs with $3/4$-inch lath channel welded on and covered with expanded metal lath. Wall channels are tied in to brick work with $1 \times 1/16$-inch galvanized strips welded to the far flange of the channel and brought into the brick work with a two-way bend to take care of differences in expansion of the steel frame and the brick work. The strips are corrugated where they fit into the brick work in order to take a firm hold in the mortar. Studs are spaced 30 inches apart with the web of the channel perpendicular to the wall. The channels are tied into the brick work at every seventh course of brick. There is a spacing of approximately $3/4$ inch between channel studs and brick work. Expansion joints are located in two places in the concrete roof from front to back.

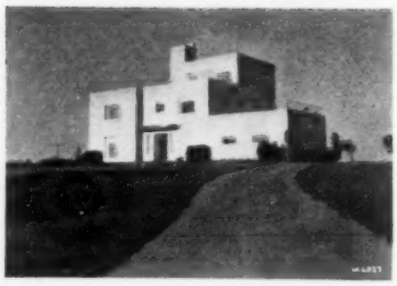


Fig. 1—View of Arc-Welded Steel Framed Residence

The method of erection utilized a boom crane on the back of a truck. (See Fig. 2.) This crane handled and placed the shop fabricated sections of the framework, some of which were three stories high. Figure 3 shows the steel framework being

Fig. 2 (Top)—Erecting the Steel Frame in Shop-Fabricated Sections by Use of Boom Crane on Back of Truck

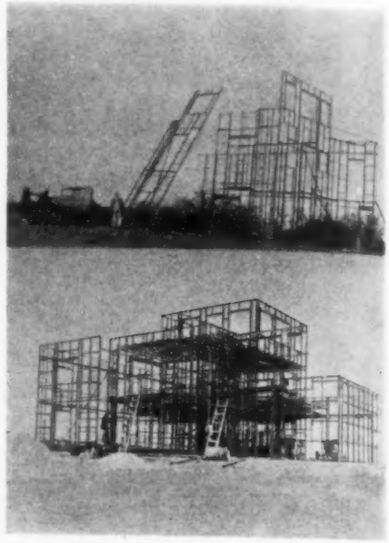


Fig. 3 (Bottom)—The Steel Frame Being Arc Welded

National

Carbide

DEPENDABLE

EFFICIENT

ECONOMICAL

FOR WELDING and CUTTING

Use National Carbide in the Red Drum

Lincoln Building — NATIONAL CARBIDE CORPORATION — New York, N. Y.

for better welds *and faster welding*

● Jobs like the reinforcing of bridge members, as pictured above, are done in record time with Page Hi-Tensile "F". The welds are strong and ductile. They resist the effects of heavy vibration.

● Page Hi-Tensile "F" is an all-purpose electrode with a reputation for reducing fabrication costs. It is perfectly suited to construction, maintenance, production work. It saves a lot of time on high-speed, single-pass welding and on jobs in Cor-ten, Cro-man-sil, H-T-50 and other new alloy steels.

BUY ACCO QUALITY *in Page Welding Electrodes, Page Chain Link Fence, TRU-LAY Preformed Wire Rope, Reading-Pratt & Cady Valves, Campbell Abrasive Cutting Machines, American Chains (Welded and Weldless) and Wright Hoists.*

PAGE STEEL AND WIRE DIVISION • MONESSEN, PENNSYLVANIA

AMERICAN CHAIN & CABLE COMPANY, Inc.

AMERICAN CHAIN DIVISION • AMERICAN CABLE DIVISION • ANDREW C. CAMPBELL DIVISION • FORD CHAIN BLOCK DIVISION • HAZARD WIRE ROPE DIVISION • HIGHLAND IRON AND STEEL DIVISION • MANLEY MANUFACTURING DIVISION • OWEN SILENT SPRING COMPANY, INC. • PAGE STEEL AND WIRE DIVISION • READING-PRATT & CADY DIVISION • READING STEEL CASTING DIVISION • WRIGHT MANUFACTURING DIVISION • IN CANADA: DOMINION CHAIN COMPANY, LTD. • IN ENGLAND: BRITISH WIRE PRODUCTS, LTD. • THE PARSONS CHAIN COMPANY, LTD. • *In Business for Your Safety*

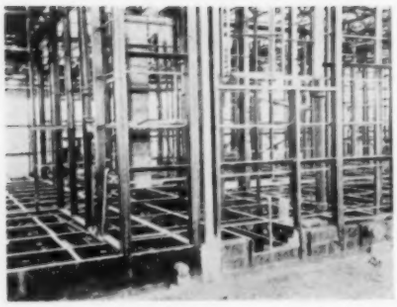


Fig. 4—Close-up of Some of the Arc-Welded Frame

arc welded. Figure 4 shows a close-up of the arc-welded frame.

The metal lath used on the outside walls was backed up with paper and metal foil for insulating purposes. The space between the studs in the metal framework was filled with rock wool. The insulation system, which also utilized a special paint to seal the pores of the brick veneer, makes it possible to hold the interior temperature of 85° with an external temperature of 110° with only a 5 horsepower motor in the air-conditioning system.

WELDING GOES TO THE TOURNAMENT OF ROSES PARADE

What is considered the most magnificent float that has ever been entered in the famous Pasadena Tournament of Roses Parade was the one entered by the City of Burbank—winner of the Grand Sweepstakes prize of 1939. This particular float

will also be exhibited at the San Francisco World's Fair.

The framework for the horses on this float was welded by three students of the Burbank Junior High School under the direction of Mr. R. C. Davis, their instructor. Over the welded steel framework was placed a layer of chicken wire, then plaster of Paris, and then the entire float was solidly covered with flowers. *Photos courtesy Victor Equipment Co.*

DELIVERED DURING A SNOW STORM

A house a la carte. A new Williamsburg model, all arc-welded steel house goes to its site in Edgehill Village, a new all steel

subdivision. Attractive six room, authentic Williamsburg home of the latest model of new steel houses. *Photo courtesy Hobart Brothers.*

AN ALL-WELDED PRESSURE VESSEL

The Ben Sibbitt Iron & Foundry Company, of Wichita, Kansas, has completed the fabrication, by electric arc welding, of the first of several large pressure vessels for a western petroleum refinery. This particular vessel is 35 feet long; seven feet, six inches in diameter; and was fabricated of $^{3}/_{8}$-inch flange-quality steel

"DREDNAUT-50-S" Welding Goggles are Cool—Comfortable—Safe!

COOL—because the eye cups are so constructed as to provide a satisfactory method of ventilation.

COMFORTABLE—because right and left eye cups are constructed with a broad bearing surface which distributes the weight of the goggles and enables them to be worn with comfort without cutting the face.

SAFE—because Drednaut Welding Goggle frames are made of a patented molded material that is very light in weight, has great tensile strength, is water-proof, non-inflammable and non-conductive to electrical current. They are fitted with Drednaut Welding Lenses that provide complete protection against the injurious Infra Red and Ultra Violet rays.

Drednaut 50-S Welding Goggles are further equipped with our Non-Rubber Headband which contains no rubber yet maintains the desired tension indefinitely, once adjusted, it stays adjusted, will not stretch out of shape, and is not affected by perspiration, oil or grease.

TO MANUFACTURERS, JOBBERS AND DEALERS of Electric and Oxy-Acetylene Welding Equipment and Supplies—if interested in distributing our line of safety equipment, write us for Catalog and full details of our proposition.

Write for descriptive literature and prices.

THE SAFETY EQUIPMENT SERVICE CO.

BUELL W. NUTT, *President* • • • **1228 St. Clair Ave., CLEVELAND, OHIO**

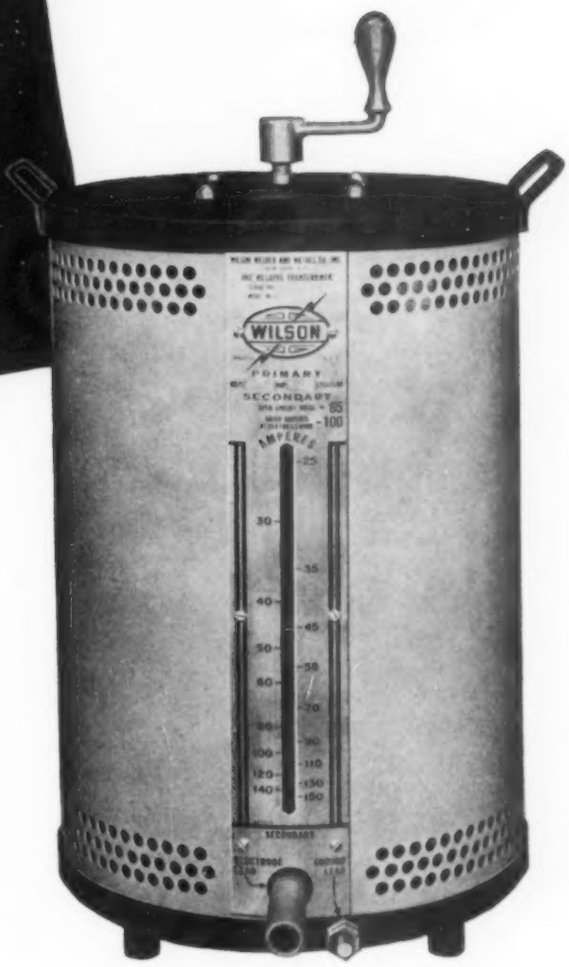
Manufacturers of a General Line of Accident-Prevention Equipment

Good news!

THE NEW 100 AMPERE ALTERNATING CURRENT ARC WELDER

WILSON

TRANSFORMER TYPE — MODEL MCT



Height — approx. 27". Diameter — 14".
Net Weight — 145 lb.

Specially developed to meet the widespread demand for a small A.C. arc welder, this new WILSON machine satisfies the demand from every angle — including PRICE. It's a TOP-NOTCH QUALITY machine throughout, with a design and construction that assures trouble-free performance, all day and every day. STEPLESS CURRENT CONTROL is an outstanding feature. By simply turning the handle on top, *any* current from 25 amps. to the maximum of 150 can be set, while the machine is idling or under load. Fully meets the requirements of the latest re-examination service of UNDERWRITERS LABORATORIES, INC. and bears the official label.

Rated Output: 25 volts, 100 amps., 65 volts open circuit (½ hour, 70°C rise) Standard machine operates on 220 volts, single phase, 60 cycles. Can be supplied for 110 volts or 440 volts at no extra cost.

For further details, write for Bulletin MCT 39.

WILSON WELDER and METALS CO., Inc.

General Offices: 60 East 42nd Street, New York City

Distributed through AIR REDUCTION Sales Company
DISTRICT OFFICES IN PRINCIPAL CITIES

WILSON **ARC WELDERS — *"The machines that make the arc behave"***

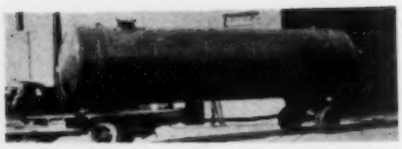


plate. The heads were constructed of $^1/_2$-inch steel plate of the same quality. All seams were butt welded. Welding operators were qualified for all-position welding by the Kansas State Highway Department.

After fabrication, the vessel was given a hydrostatic test with water at a pressure of 150 pounds per square inch and 60° F. With this pressure on the vessel, it was hit sharply, on each side of each seam, at six-inch intervals, with a three-pound hard brass hammer. The vessel was then checked under A. P. I.-A. S. M. E. specifications and showed no signs of leaks or sweats.

NEW ORLEANS A. S. M. E. SPRING MEETING

Industrial development and progress in the South will be the main subject of many of the technical papers to be presented at the A. S. M. E. Spring Meeting in New Orleans, Feb. 23rd to 25th, inclusive. Everything points to a meeting which to most of those who attend will prove unique. The problems of the engineer in the South are peculiarly his own and not only will certain of these problems be considered at the technical sessions, but every effort is being made by the Meeting Committee to give members an opportunity to visit industrial plants and to witness engineering construction work typical of the industries and undertakings of that part of the country.

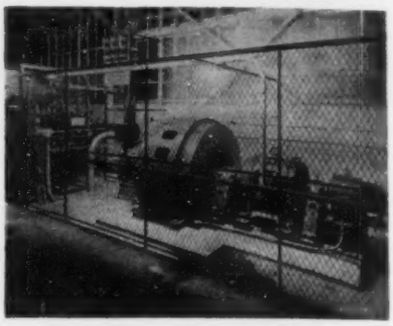
TORCH MACHINE

The Hayes Track Appliance Co., Richmond, Indiana, has issued a very unique and attractive catalog describing their Torch Machine and the methods used in guiding the torch. Copies will be sent on request.

SUPPLYING POWER FOR SINGLE-PHASE RESISTANCE WELDERS

Importance of adequate power supply for single-phase welding circuits of high capacity has become generally recognized only recently. For several years motor-driven single-phase generators have been used for practically every type of welding service. Using experience derived from the performance of these generators as a basis, R. H. Wright, of the Westinghouse Company, discussed the correct application of conversion equipment for future applications in welding before the recent A.I.E.E. winter convention in New York.

Simple apparatus gives excellent service in many instances. The use of generators with specially designed single-phase windings is preferable to using one phase of a three-phase machine. Because of the vibration usually inherent in single-phase machines, welding generators should not be overlooked consistently. Output voltage can be controlled more readily, if the peak load is not greatly in excess of the normal capacity of the generator. The rated power factor of welding generators ranges from 30 per cent for spot welders to 60 or 70 per cent for butt and flash welders. For some applications it is desirable to operate more than one welder from a single generator. Two or more spot welders with electronic timers can be operated from a single generator of minimum capacity, if an electronic synchronizing device is used to permit only one welder to be energized at one time. Such an arrangement introduces no appreciable delay in production, since each welder in turn is locked out for only a fraction of a second.



A 700-Kva. Single-Phase Spot-Welding Generator Operating at 0.30 Power Factor, with a 150-Horsepower Squirrel-Cage Driving Motor. A Squirrel-Cage Motor with a Small Amount of Slip Utilizes the Flywheel Effect of the Set to Equalize Peaks and Insure Stable Operation

SAFE! JACKSON
INSULATED Electrode Holder

Protect your welders, avoid work spoilage, speed your operations by using Jackson Insulated Electrode Holders —made in three capacities.

We also have four non-insulated models at attractive new low prices. Ask your dealer.

Model A-2—300 amps.—1/16" to 1/4" rods. Replaceable jaws of Mallory 3 Metal. Ask your dealer.

JACKSON ELECTRODE HOLDER CO.
15122 MACK AVENUE DETROIT, MICHIGAN

Hollup Corporation, Ltd., 107 Atlantic Avenue, Toronto, Ont.
Paragon Supplies, Ltd., 845 East Hastings St., Vancouver, B. C.
Export Managers:
International Technique, 381 Fourth Ave., New York, N. Y.

More good news!

THE NEW WILSON 150 AMPERE D. C. MOTOR-GENERATOR ARC WELDER

Small in Size
Low in Price
BIG in Performance

This new WILSON unit represents as fine a value as has ever been offered in an arc welder of its type and capacity. In ease of operation and welding performance with either bare or coated electrodes, it leaves nothing to be desired. The illustration shows clearly its simple, sturdy construction and business-like compactness. It takes up less than 2½ square feet of floor space, and stands only a fraction over 23 inches high. Built "close to the ground" it can be moved around freely. Like all WILSON Arc Welders, this machine can be depended on for years of hard service and complete satisfaction.

Rated Output: 25 volts, 150 amps., ½ hour continuous welding duty. Higher current values for shorter periods. 40 to 75 volts open circuit.

Operates on 220 or 440 volts, 3 phase, 60 cycles.

Net Weight: For stationary use, 330 lb. For portable use, 338 lb.

For further information, write for descriptive Bulletin.

WILSON WELDER and METALS CO., Inc.

General Offices: 60 East 42nd Street, New York City

Distributed through AIR REDUCTION Sales Company
DISTRICT OFFICES IN PRINCIPAL CITIES

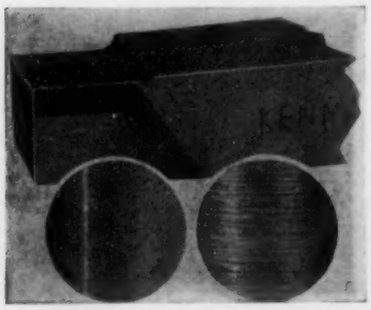
WILSON **for Everything needed in Arc Welding**

NEW PRODUCTS

The Society assumes no responsibility for the validity of claims in this Section

CUTTING METALS

A new, reliable, hard carbide alloy for machining tough metals such as steel, heat treated up to 500 Brinell, which combines roughing and finishing in one operation, is now being supplied under the trade name of "Kennametal" by the McKenna Metals Company, 194 Lloyd Ave., Latrobe, Pa. The basic ingredient is tungsten-titanium carbide (WTiC2) and the new alloy may also be used in machining

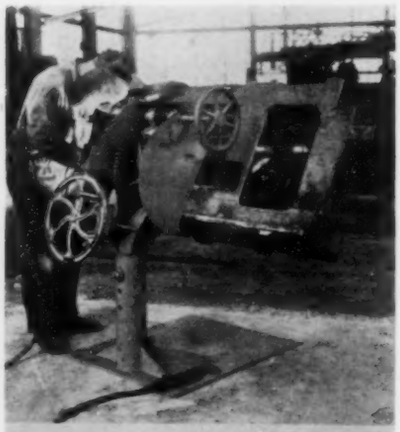


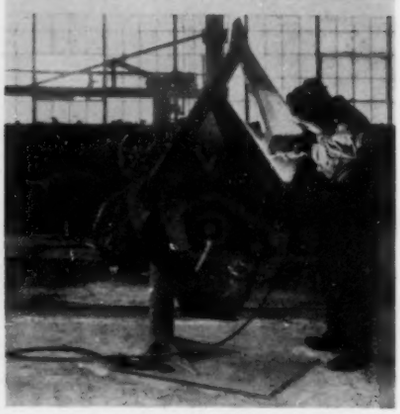
monel metal, malleable iron, cast iron, brass, bronze, aluminum, etc.

BETTER WELDS AT LOWER COST
Welding Positioner

With the C-F Welding Positioner better welds are made at lower cost because the job can be properly positioned easily and quickly.

The positioner permits welding on the sides, top and bottom of a job with only one set-up. Table can be tilted a total of 135° from horizontal, or 45° beyond vertical position. (See illustrations.) Table can be rotated through full circle regardless of angle at which it is tilted.





This makes it possible to properly position all welds of a job for down-hand welding without re-handling.

Overhead crane or hoist lifts are greatly reduced releasing that equipment for other work. Also welders time waiting for crane service is cut.

Safer—possibility of accidents is reduced by less handling of individual jobs. Cullen-Friestedt Co., 1307 S. Kilbourn Ave., Chicago, Ill.

WELDING HELMETS AND HAND SHIELDS

Four new welding helmets and four new hand shields have just been announced by the American Optical Company, Southbridge, Mass. These helmets and hand shields are made of the best grade vulcanized fiber, in either fabricated or one-piece construction, and are designed for comfort, safety, convenience and durability.

The helmets have a new free-floating headgear and an outside friction joint as standard equipment. Three types of glass holders are available: Deep-Drawn Leakproof Steel, Improved Bakelite and the new Dowmetal Lift Front, all of which assure maximum protection for welding plates and cover glass. An exclusive feature will be noted in these holders: they hold the welding and cover glass in position flexibly, not rigidly, in order to cushion the shock if accidentally struck. Glass can be easily changed without smudging or risk of breaking.

The hand shields are compact, lightweight and well-balanced. Corrugated fiber handle, of new design, is deeply grooved to insure a firm, positive grip.

HYDRAULICALLY OPERATED CLUTCH

A new hydraulic clutch of unusual merit has recently been developed by Fray-Mershon, Inc. and associates of Glendale, California. The new "Hydra-Clutch" has many outstanding features to meet all operating conditions. The clutch is intended for such as bull-dozing, carry-all work, winches, hoists, etc.

SPEED CONTROL

Alvin F. Brunkow, of Alma, Wisconsin, has patented a speed control for engine driven arc welding machines. His patent is number 2,139,931.

With this device the welding machine may run at a low idling speed of 400 r.p.m., or even lower, for instance when the operator is not welding.

The idling speed can be adjusted to any

Buy "Proven Fluxes" with Years of Guaranteed Satisfaction behind them
The Trade-Name is "ANTI-BORAX"

Ask For Them *Unequaled for Quality*

A Flux for every metal: Cast Iron Welding Flux No. 1.; Brazing Flux No. 2; Braz-Cast Flux No. 4, for bronze-welding cast iron; "ABC" Aluminum Flux No. 8 for sheet Aluminum and all alloys of Aluminum; Stainless Steel Flux No. 9; Silver Solder Brazing Flux No. 10; "Anti-Borax" Tinning Compound No. 11.

Send for Free Samples

ANTI-BORAX COMPOUND COMPANY
Fort Wayne, Indiana

REGO
WELDING AND CUTTING EQUIPMENT
- Welding Torches
- Cutting Torches
- Economizers
- Regulators
- Outfits

FOR PLUS PROFIT SPECIFY REGO
Send for Catalog R-120 — with it you will have all the specifications you need for the buying of highest quality welding and cutting equipment.
The BASTIAN-BLESSING Company
282 E. ONTARIO ST., CHICAGO

"To say I'm sold on Tobin Bronze is putting it mildly. For more than 20 years, I have used this welding rod... and today all of us prefer it to any other. Why? Because Tobin Bronze is more economical to use and helps my men make better, more dependable welds."—C. G. Blackwell, Dayton Welding Co., Dayton, Ohio.

Broken castings made "like new"

Tobin Bronze enables welders to reclaim broken castings which otherwise would need to be replaced at great expense

The danger of cracking and warping prohibited the use of methods involving preheating for the welding of this unsupported cast-iron platform. Tobin Bronze made furnace preheating unnecessary and the low welding temperature minimized risk of distortion and shrinkage.

A thrilling book could be written of the many spectacular "rescues" made by welders with the aid of Tobin Bronze! A wheel or other part breaks... the factory is at a standstill... the only solution seems to be a new part. Faced with a long shutdown and high expense, someone who "knows" suggests Tobin Bronze Welding.

Straightway the broken casting is made "like new" at ridiculously small expense.

Extensive preheating is usually unnecessary for Tobin Bronze welding. Welds are made by heating the surface of the weld area to a red heat only. Thus Tobin Bronze welding saves time, gas and money, and reduces the possibility of distortion.

This time-tried Anaconda welding rod carries the trade-mark "Tobin Bronze registered U. S. Patent Office" on each rod. Look for it—get the genuine.

ANACONDA

SR247

Anaconda Welding Rods

THE AMERICAN BRASS COMPANY, General Offices: WATERBURY, CONNECTICUT

Offices and Agencies in Principal Cities • In Canada: ANACONDA AMERICAN BRASS LTD., New Toronto, Ontario

desired idling speed up to welding speed by a hand screw without interfering or changing the operating or welding speed. This is an important feature, especially when welding with a cold engine, and different welding requirements may call for a higher idling speed.

BEACHING GEARS FOR NEW TRANS-PACIFIC 74-PASSENGER PLANES ARE ALL WELDED

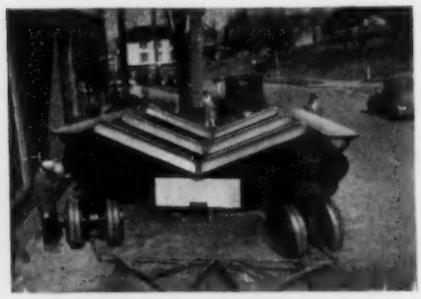
Recent introduction of the new Boeing model 314's—74-passenger ocean-spanning planes—resulted in the construction of a distinctly new type of beaching gear to be used in bringing these huge flying boats out of the water and up into the hangar for maintenance and repair.

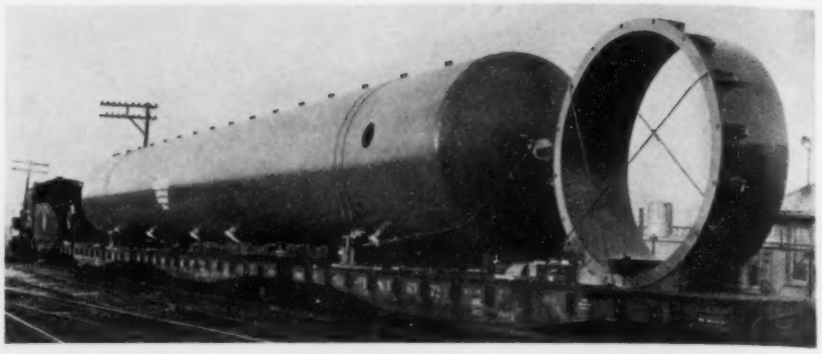
These Boeing Model 314 74-passenger planes weigh 82,000 lb. and when lifted from the water this great load must be applied to the hull without the slightest tendency on the part of the lifting device to deflect—otherwise the hull might be severely damaged.

The Kenworth Motor Truck Corporation of Seattle, Washington, undertook the task of producing such a lifting mechanism. Heavy cradle type trailers were fabricated from steel sections. Arc welding was resorted to in order to produce a rigid, unit-type structure free from open joints subject to slip or weave under load.

The accompanying photograph shows one of the finished gears. They are 23 ft. in length, 18 ft. wide and 7½ ft. in height. Each weighs 15 tons and is entirely welded throughout—employing over 1200 ft. of welding in each.

The airplane hull rests in a cradle of cross members, each member cushioned with rubber pads.





These gears are designed to carry a load in excess of 87,000 lb. Each side of the gear is fitted with pontoons with air locks for inflation beneath the floating airplane hull. There is a plus buoyancy of about 2000 lb. at the water surface.

The gear is stopped by means of ratchet brakes located on the four front wheels. The spindles are constructed to rotate 360 degrees and to toggle 10 degrees.

The rigidity of these structures is of unusual interest. The diagonal deflection, loaded, is $^{5}/_{32}$ of an inch. This is equivalent to suspending 20 tons on the end of a 12-ft. arm with a deflection of only $^{5}/_{32}$ of an inch. Such rigidity is typical of welded, unit-type structural steel machinery— is one of the most important reasons behind the rapid increase in the use of electric arc welding. Photo Courtesy, Harnischfeger Corporation, Milwaukee, Wisconsin.

NEW WELDING CATALOG

The Champion Rivet Company, Cleveland, Ohio, has just issued an unusually attractive welding catalog giving technical information concerning the applications and use of each type of their electrodes, including, recommended procedure and physical properties which can be expected. Other pertinent technical information included. The catalog consists of 64 pages handsomely illustrated.

PRESSURE VESSEL

An oil refining tower of exceptionally large size is shown here being loaded at the A. O. Smith Corporation's Milwaukee plant for shipment to a Pennsylvania refinery.

This enormous vessel is Smithlined throughout with chromium alloy steel as a protection against corrosion. It will stand more than 108 ft. high and is 11 ft. in diameter. Its huge size necessitated use of three special railroad cars for shipment. The supporting skirt in the foreground will be bolted to the vessel in service.

1938 BOUND VOLUME JOURNAL NOW READY!

This volume of more than 1200 pages is bound in attractive imitation leather covers with subject and authors index. Price $6.50 to non-members plus postage. $5.00 to members plus postage.

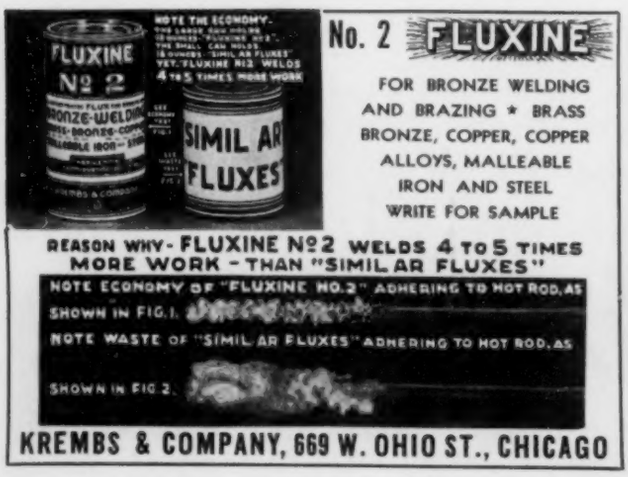
ELEVENTH WELDING CONFERENCE

Iowa State College
Tuesday, Wednesday and Thursday
March 21, 22 and 23, 1939

The conference program will consist of talks, demonstrations, and discussions of electric arc welding and oxyacetylene welding and cutting. Individual problems will be given special attention. There will be a large exhibit of welding equipment and supplies.

There are no fees, and any one interested in welding is invited to attend.

Write Engineering Extension Service, Iowa State College, Ames, for program or other information.


FLUXINE
Nº 2
BRONZE-WELDING
SIMIL AR
FLUXES
No. 2 FLUXINE
FOR BRONZE WELDING AND BRAZING ★ BRASS BRONZE, COPPER, COPPER ALLOYS, MALLEABLE IRON AND STEEL
WRITE FOR SAMPLE
REASON WHY- FLUXINE Nº2 WELDS 4 TO 5 TIMES MORE WORK - THAN "SIMIL AR FLUXES"
NOTE ECONOMY OF "FLUXINE NO.2" ADHERING TO HOT ROD, AS SHOWN IN FIG. 1.
NOTE WASTE OF "SIMIL AR FLUXES" ADHERING TO HOT ROD, AS SHOWN IN FIG. 2.
KREMBS & COMPANY, 669 W. OHIO ST., CHICAGO

And Now, a Modern
ELECTRODE
McKAY
SHIELDED ARC WELDING Electrodes
The right electrode and the right method for each job are the keys to successful welding. Every modern resource is employed to improve McKay Electrodes and to aid the user. Ask for folder.
The McKay Company
McKay Building
Pittsburgh, Pa.

New!

P.R. MALLORY & CO. Inc. MALLORY 333 Metal

A Copper Alloy Combining Higher Conductivity and Greater Hardness than Any Other Material!

Mallory 333 Metal is a copper-chromium-lithium alloy developed and patented exclusively by Mallory. It offers qualities never before available in combination . . . plus substantial savings in cost.

The incorporation of lithium is the real reason for the great superiority of Mallory 333 Metal. Lithium is only half as heavy as water and has the lowest density of any metallic element. It is the greatest deoxidizer and degasifier ever developed, and has an extremely high affinity for all impurities in a copper melt.

Mallory 333 Metal is invaluable in wrought form for welding electrode use . . . and in castings, the scope of its application is practically unlimited. Current-carrying reeds, springs, terminals and studs, connectors, collector rings, line hardware, circuit breaker parts, arc welding electrode holding jaws, sliding contacts, structural parts of high frequency and carbon arc furnaces . . . these are just a few of the applications to which the super-hardness and higher conductivity of Mallory 333 Metal makes the greatest contribution ever offered.

Mallory 333 Metal insures sounder, cleaner castings and permits more complicated coring and thinner walls than were ever possible before. Mallory 333 Metal can easily be the alloy for which you have long been seeking. Get complete details now!

P. R. MALLORY & CO., Inc., INDIANAPOLIS, INDIANA

Cable Address — Pelmallo

P.R. MALLORY & CO. Inc. MALLORY

NON-FERROUS ALLOYS and ELECTRICAL CONTACTS

List of New Members

January 1 to January 31, 1939

BIRMINGHAM

White, F. Erskine (C), Birmingham Fabricating Co., Birmingham, Ala.

BOSTON

Brummitt, P. W. (D), 49 Rogers St., Quincy, Mass.
Casavant, Aime N. (C), 85 High St., Amesbury, Mass.
Costello, Thomas A. (D), 23 Keith St., Weymouth, Mass.
Henley, Richard (D), Bethlehem Steel Co., Fore River Plant, Quincy, Mass.
Jones, R. Warren (C), Foundry St., South Easton, Mass.
Ruel, Herbert N. (D), 34 Ivy Road, S. Weymouth, Mass.
Rusky, Nicholas (D), Hancock Terrace, Wollaston, Mass.
Sherriff, James (D), 99 Goddard St., Quincy, Mass.
Whitley, Wilson W. (D), 87 Hudson St., Sommerville, Mass.
Winship, Robert H. (D), 58 Stewart St., Quincy, Mass.
Yeadon, John R. (D), 48 Myrtle St., Lynn, Mass.

CANTON

Switzer, De Vere (C), Firestone Park Sta., Box 2683, South Akron, Ohio.

CHATTANOOGA

Alexander, Jas. F. (C), 813 Barton Ave., Chattanooga, Tenn.
Freeman, P. J. L. (C), 3101-14th Ave. Chattanooga, Tenn.
Lane, Ralph S. (C), 951 E. 13th St., Chattanooga, Tenn.
Weigel, John H. (C), 207 Robinson Apts., Chattanooga, Tenn.
Winthorpe, James (C), 4117 Tennessee Ave., Chattanooga, Tenn.

CHICAGO

Bacon, Harold (D), 6260 Stony Island Ave., Chicago, Ill.
Brucks, H. (D), 8027 Indiana Ave., Chicago, Ill.
Callas, Henry (D), 4437 Shields Ave., Chicago, Ill.
Cody, Louis (D), Whiting Corp., Harvey, Ill.
Daniels, H. J. (D), 2116 W. Jackson Blvd., Chicago, Ill.
Fink, K. (D), 2626 S. Harding Ave., Chicago, Ill.
Gleich, W. J. (D), 6505 Stewart Ave., Chicago, Ill.
Grot, A. S. (C), 5014 West End Ave., Chicago, Ill.
Harbin, Peter L. (D), 5340 W. 24th Place, Cicero, Ill.
Hjulin, Paul (D), 10318 Indiana Ave., Chicago, Ill.
Jumbalo, S. J. (D), 5304 W. 22nd Place, Cicero, Ill.
Lange, Frank (D), 711 So. 2nd Ave., Maywood, Ill.
Livingston, John (D), 4335 W. 17th St., Chicago, Ill.
Locum, Edward (D), 11929 S. Union Ave., Chicago, Ill.
Lytikainen, Elmer John (D), 2115 S. 2nd Ave., Maywood, Ill.
Martin, Wm. (D), 1319 S. 50th Court, Cicero, Ill.
Nordine, A. (D), 306 W. 108th Place, Chicago, Ill.
Poston, Claude P. (D), 6203 S. Whipple St., Chicago, Ill.
Schneider, Charles A. (C), 9349 S. Justine St., Chicago, Ill.
Sheridan, S. A. (D), 13447 Houston St., Chicago, Ill.
Sloan, John (D), 1418 Summerdale Ave., Chicago, Ill.
Smith, A. E. (D), General Delivery, Midlothian, Ill.
Valenta, G. (D), 5528 W. 23rd Place, Cicero, Ill.
Walker, R. W. (D), 4631 W. 19th St., Cicero, Ill.
Wiles, John, Jr. (D), 658 Englewood Ave., Chicago, Ill.
Wozniak, J. (D), 4817 W. 24th St., Cicero, Ill.
Wright, John P. (B), International Filter Co., 329 W. 25th Place, Chicago, Ill.

CINCINNATI

Lockeman, G. F. (C), The Procter & Gamble Co., Ivorydale, Ohio.

CLEVELAND

Burnett, Robert R. (D), 15457 Euclid Ave., Suite 11, East Cleveland, Ohio.
Frantz, Lloyd (D), Lincoln Elec. Co., Coit Rd. & Kirby Ave., Cleveland, Ohio.
Miller, Lee K. (C), 22570 Ivan Ave., Euclid, Ohio.

COLORADO

Weinberger, E. W. (B), 410 Pearl St., Denver, Colo.

COLUMBUS

Scarbery, Jasper L. (B), 4220 Cleveland Ave., Columbus, Ohio.

INDIANAPOLIS

Throckmorton, Ralph E. (F), 355 W. Oak St., W. Lafayette, Ind.

LOS ANGELES

Booth, C. E. (D), 8211 Walnut Dr., Los Angeles, Calif.
Buehler, Walter (B), 5000 Pacific Blvd., Los Angeles, Calif.
Dexter, D. O. (D), 2938 Cudahy, Huntington Park, Calif.
Govi, Joe (D), 6368 A Arbutus St., Huntington Park, Calif.
Kennon, Lorenzo (B), 376¾ S. Lona Dr., Los Angeles, Calif.
Keptner, Thomas C. (C), 337 W. 73rd St., Los Angeles, Calif.
Miller, Ray (D), 1517—76th Place, Los Angeles, Calif.
Patterson, Donald W. (D), 2568 Indiana Ave., South Gate, Calif.

MARYLAND

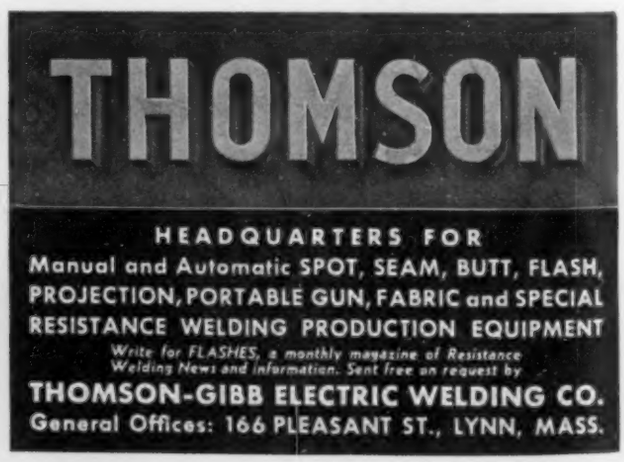
Scheerer, Carl F. (D), 316 S. East Ave. Baltimore, Md.

MILWAUKEE

Grant, Leland E. (B), Chicago, Milwaukee, St. Paul & Pac. R.R., Milwaukee Shops, Milwaukee, Wis.
Noe, William A. (D), Rt. 3, Box 404, Racine, Wis.
Walbridge, Robert P. (D), 5425 N. 39th St., Milwaukee, Wis.

NEW YORK

Aumann, Henry (D), 330 W. 12th St., New York, N. Y.
Bearor, Theodore (D), 244 W. 101st St., New York, N. Y.
Borner, Fred (C), 1309 Boulevard, Broad Channel, L. I.
Fieger, Max (B), American Trade Schools, Inc., 789 Broad St., Newark, N. J.


THOMSON
HEADQUARTERS FOR
Manual and Automatic SPOT, SEAM, BUTT, FLASH, PROJECTION, PORTABLE GUN, FABRIC and SPECIAL RESISTANCE WELDING PRODUCTION EQUIPMENT
Write for FLASHES, a monthly magazine of Resistance Welding News and information. Sent free on request by
THOMSON-GIBB ELECTRIC WELDING CO.
General Offices: 166 PLEASANT ST., LYNN, MASS.

WELDING ECONOMY BEGINS WITH

INVESTIGATE THESE ECONOMY FEATURES:

1. Built-in Arc Watchman
2. Voltage fluctuations do not alter current
3. Pre-set single dial current control
4. Current does not change when machine heats up
5. Safe—lowest open circuit voltage
6. Improved method of Polarity Reversal
7. New accuracy and speed in overhead welding. A generator designed only for arc welding.
8. Elimination of parts that require excessive maintenance
9. Armored construction
10. Unlimited number of current steps

In the Flexarc machine, current is accurately controlled by the Arc Watchman. Operation of the machine for any type of welding is simplified to one dial, one control.

This different principle of arc control in your welding operations saves money for you three ways:

1. Gets more welding done per day, saving time in adjusting and readjusting controls, and chasing back and forth from the business end of the cable to the machine.
2. Stabilizes current and deposits more metal per hour.
3. Eliminates rheostats, reactors, exciters and other devices that require excessive maintenance.

You will be interested in a new booklet—"Westinghouse Cuts the Knots in Arc Welding." Make a note to send for your free copy today.

WESTINGHOUSE ELECTRIC & MFG. COMPANY, EAST PITTSBURGH, PA.

J20642

Westinghouse Flexarc

Frantzen, C. (B), 425 Chapman St., Irvington, N. J.
Gibson, C. C. (D), 40th Ord. Co., Raritan Arsenal, Metuchen, N. J.
Piasecki, Stanley (D), 80½ Attorney St., New York, N. Y.
Reynolds, Joseph (D), 89 Riverview Ave., Tarrytown, N. Y.
Russell, Kenneth (D), % Sailors Snug Harbor, Staten Island, N. Y.
Selvatico, D. M. (D), 40th Ord. Co., Raritan Arsenal, Metuchen, N. J.
Smith, Philip (D), 217 York Ave., Brighton, S. I., N. Y.
Valdes, Joseph (D), Company E, Governors Island, New York, N. Y.
Wunder, Leon (D), 123 Lewis St., New York, N. Y.

NORTHERN NEW YORK

Morenus, D. M. (D), 915 Michigan Ave., Schenectady, N. Y.
Wyant, Robert A. (C), Rensselaer Polytechnic Inst., Dept. of Metallurgy, Troy, N. Y.

WESTERN NEW YORK

Bos, John, Jr. (B), 1318 Elk St., Buffalo, N. Y.

NORTHWEST

Tomczyk, Joseph (D), 447 Jefferson St., Minneapolis, Minn.

OKLAHOMA CITY

Cornwall, Francis (D), Route 6, Box 277, Oklahoma City, Okla.
Reynolds, Ralph C. (D), J. B. Klein Iron & Fdry. Co., 1401 N. W. 3rd St., Oklahoma City, Okla.
Smith, Stanley (D), J. B. Klein Iron & Fdry. Co., 1401 N. W. 3rd St., Oklahoma City, Okla.

PEORIA

King, E. Doyle (D), R.R. 1, McCarty Acres, Peoria, Ill.
Stoller, Ed. (D), 619 W. Callendar Ave., Peoria, Ill.

PHILADELPHIA

Brady, Edward J. (B), % McKay Co., Grantley Road, York, Pa.

PITTSBURGH

Grabe, C. G. (B), National Valve & Mfg. Co., 3101 Liberty Ave., Pittsburgh, Pa.
McCuen, Harper (D), P. O. Box 243, Imperial, Pa.

ROCHESTER

Bick, Richard R. (D), 25 Park Ave., Dansville, N. Y.
O'Neil, John J. (D), 44 Main St., Dansville, N. Y.

ST. LOUIS

Long, Richard H. (B), Mutual Boiler Ins. Co., 4 N. 8th St., St. Louis, Mo.

SAN FRANCISCO

Hanna, Richard R. (C), 2217 Scott St., San Francisco, Calif.

WASHINGTON, D. C.

Hamill, Thomas E. (C), Naval Gun Factory, Washington, D. C.
Whitehead, Edward (B), Taylor-Winfield Corp., 1025 Investment Bldg., Washington, D. C.

WICHITA

Jones, Paul (D), Paul Jones Welding & Mach. Shop, Eureka, Kansas.

YOUNGSTOWN

Hurcomb, F. A. (B), 687 Trumbull Ave., Warren, Ohio.

NOT IN SECTIONS

Henderson, Henry F. (C), The Portland Company, 58 Fore St., Portland, Maine.
Ladd, Wendell (D), % F. O. Ladd, Paton, Iowa.
Lowener, V. (C), Vesterbrogade 9 B, Copenhagen, Denmark.
McLaughlan, O. B. (A), Freeport Sulphur Co., Port Sulphur, La.
Moore, Clarence H. (C), 2130 Laura St., Jacksonville, Fla.
Moore, R. S. (C), Air Reduction Sales Co., 1256 Logan St., Louisville, Ky.
Osburn, E. R. (B), Texas-New Mexico Pipe Line Co., Box 360, Midland, Texas.
Smith, Charles F. (D), % Thibodaux Boiler Wks., Darrow, La.
Tweed, R. (B), P. O. Box 427, Calcutta, India.

EMPLOYMENT SERVICE BULLETIN

SERVICES AVAILABLE

A-301. Metallurgical Engineer. Ph.D., Married. Fifteen years experience in application and fabrication of corrosion and heat resisting steels and alloy steels, desires position as research engineer or engineer of tests. Inspection, preparation of specifications, sales and promotional experience. Eastern location preferred.

A-302. Welder with two years experience in Electric Arc and Gas Welding, Brazing and Cutting. Can weld in all positions. Experienced in repair, shop work and bridge welding. Can give references. Prefer Electric Welding job.

A-303. Welding Engineer, 10 years experience in design of special equipment for welding and design of shielded arc or flux covered electrodes. Desires opening as Welding Specialist, Research Engineer or Welding Supervisor.

A-304. Combination welder, 9 years experience, shop and field work; two years college education, Mechanical Engineering. Will go any place.

A-305. Ph.D. experienced in all electric arc welding problems. Experience covers welding and coating chemistry, metallography, fabrication process, research laboratory. Has been technical manager of an important European electrode manufacturer. References in America and Europe.

A-306. Welder desires position Extensive experience in Arc and Gas Welding, including job shop welding, all metals and alloys, automobile repair welding, barges, dredges, boilers, stacks and the like. Can furnish references.

A-307. Welding Supervisor desires position. Can make estimates, check materials, handle men. Excellent education. Available to go anywhere.

SAVE MONEY . . . BY WELDING

Jaw Plates, Gyratory and Roll Crushers, Shovel Teeth, Hammers, Tractor Tread Grousers
with

MANGANAL

Reg. U. S. Pat. Office. U. S. Patents 1,876,738—1,947,167—2,021,945
11 to 13½% Nickel Manganese Steel
WELDING ELECTRODES, WEDGE and APPLICATOR BARS, HOT ROLLED PLATES
STULZ-SICKLES CO. *Sole Producers* 134-142 Lafayette St., Newark, N. J.
Sold Thru Distributors Only

ALMARC ALUMINUM ELECTRODES
ALMARC FLUX
ALFLUX ALUMINUM FLUXES

FOR ALUMINUM WELDING

5% silicon aluminum rod
pure aluminum welding rods

WOOLDRIDGE ALUMINUM WELDING PRODUCTS
Glastonbury • Connecticut

» » » SECTION ACTIVITIES « « «

BIRMINGHAM

Mr. T. R. Lichtenwalter, Field Welding Engineer, Republic Steel Corp., presented an illustrated address "Welding the Stainless Steels" at the January 4th meeting of the Birmingham Section. A motion picture "Enduro—The Perfected Stainless Steel," showing the manufacture of Stainless Steel from ore to finished product, followed the address. After the motion picture, the meeting was turned into a Round Table discussion of Stainless Steel welding.

The January 16th meeting was addressed by Mr. F. C. Fantz, Vice-President, Midwest Piping & Supply Co., who spoke on "Welder Qualification and Procedure Control." In addition to Mr. Fantz, the regular speaker, Mr. C. J. Holslag, President of the Electric Arc Welding and Cutting Co., Newark, N. J., was present. The speaker handled his subject very well and the audience responded in a splendid manner.

A special meeting was called for February 1st in order to hear Mr. James F. Lincoln, President, The Lincoln Electric Company, who presented a most interesting and instructive talk on "Welding *vs.* Prejudice."

BOSTON

Mr. L. C. Poole and Mr. Leo Edelson were the guest speakers at the February 20th meeting of the Boston Section. Mr. Poole is with the Control Engineering Department of the Westinghouse Electric & Manufacturing Company and discussed the subject "Electronic Tube Control for Resistance Welding Applications." Mr. Edelson talked on "Silver Brazing with the New Sil-Fos and Easy Flow Alloys."

CHATTANOOGA

The Chattanooga Section held their regular monthly meeting at the Hotel Patten, Tuesday, January 17th. Mr. F. C. Fantz of the Midwest Piping & Supply Co., gave an interesting and well-illustrated lecture on "Welder Qualification and Procedure Control."

The February Meeting was held in the Hotel Patten Grill Room, Thursday evening, February 2nd. The principal speaker was Mr. J. F. Lincoln, President of The Lincoln Electric Company. Subject of his talk was "Welding *vs.* Prejudice."

The Chattanooga Section also sponsored a Meeting held in the office of the Compressed Industrial Gases. The principal speaker was Mr. W. C. Swift, formerly with the American Brass. His subject was "Welding of Brasses, Bronzes and Copper."

CHICAGO

The regular monthly meeting of the Chicago Section was held on January 20th in the Chicago Lighting Institute. Mr. R. T. Gillette, of the General Electric Company, discussed "Resistance Welding Methods and Control." Mr. Gillette described actual production jobs and, among other things, pointed out that the important factors of economical use and sound welding are accurate time control and synchronous switching. A special added attraction was the showing of a sound moving picture "Materials," presented by Chevrolet Motor Division, General Motors Sales Corp. A Get-Together Dinner in The Electric Club preceded the meeting.

CINCINNATI

Mr. G. O. Hoglund of the Aluminum Company of America, addressed the January meeting of the Cincinnati Section, on "Welding Aluminum." Mr. Hoglund's talk was illustrated by slides and movies. The talk was very much worth while in that it was extremely instructive and entertaining.

The February meeting was a joint meeting with the local sections of other technical societies sponsored by the Technical and Scientific Societies Council of Cincinnati.

The Section is cooperating with the University of Cincinnati in a ten week course on "Welding Design and Practice." The Evening College of the University began this course on February 6th.

The March meeting will be addressed by Mr. H. C. Fantz of the Midwest Piping and Supply Company.

The May meeting will be held in Dayton, Ohio. Annual Meeting of the Section will be held in June.

CLEVELAND

A National President's Night was held by the Cleveland Section on February 8th to welcome the President of the Society, Mr. H. C. Boardman, Research Engineer, Chicago Bridge and Iron Co. Mr. Boardman presented a very interesting talk on the subject "Large Welded Tanks of Cylindrical, Spherical and Spheroidal Shapes." Approximately 150 were present. The meeting was preceded by a dinner.

On March 8th, Professor Fred L. Plummer will address the Section at Bingham Hall, Case School of Applied Science, on "Welding Design on Main Avenue Bridge."

The Cleveland Section has appointed a Committee, with Mr. E. R. Benedict of Contract Welders, Inc., as Chairman, to make the necessary arrangements for conversion of the A. W. S. Code into the Building Code of the City of Cleveland.

The Section has decided to hold some welding symposiums in some local plants in order to permit the Section membership to witness the welding operations of the inspected plants under actual working conditions.

COLORADO

On January 10th the Colorado Section had a joint meeting with the Colorado Section of the American Society of Mechanical Engineers and the Denver Section of the American Institute of Electrical Engineers. Mr. J. F. Lincoln, President of The Lincoln Electric Company, delivered a talk on welding. About 275 members and guests of the three societies attended.

On February 8th, Mr. Clarke B. Carpenter, Professor of Metallurgy at the Colorado School of Mines, addressed the meeting on the Metallurgy of Weld Metal. The meeting was held in the Public Service Company Auditorium, Denver.

CONNECTICUT

Mr. J. F. Lincoln, President of The Lincoln Electric Company, spoke at the February 21st meeting of the Connecticut Section on "Profits *vs.* Prejudices."

DETROIT

The February meeting held on the 17th at the Detroit-Leland Hotel was addressed by Mr. H. C. Cogan, Chief Engineer, National Electric Welding Machines Company, who spoke on "Recent Developments in High Production Resistance Welders."

GEORGIA

On February 6th at the Georgia Tech Physics Laboratory, the Aluminum Company of America, under the direction of Mr. H. A. Lilly, presented a sound motion picture, "Fabrication of Aluminum."

This was one of the most interesting meetings which the Section has had, and were pleased to have about 120 visitors present.

After the presentation of the picture, Prof. Harrelson and Prof. Harrison, held demonstrations in their welding laboratory, of both torch and electric welding

of aluminum shapes. This gave those present quite a pleasurable surprise, at the thoroughness and completeness of the welding classes being conducted at the Ga. School of Technology. The meeting was in charge of Mr. D. B. Hunt, Welding Engineer of the Southern Railway.

At the March meeting, Mr. Kugler, of the Air Reduction Sales Co. will present a motion picture "First All-Welded Steel Frame School Building Constructed under Building Code of City of New York," and a paper on "Structural Steel Welding in New York City." Meeting will be held in chapel of the Ga. Tech Administration Building. Mr. Geo. T. Bird will be in charge.

KANSAS CITY

Mr. Clayton B. Herrick, Secretary of the Section, has been transferred to York, Penn. Mr. James Kirk of the Air Reduction Sales Company has been appointed by Chairman Hall to fill the unexpired term of office of Secretary, which term expires on April first.

The regular monthly meeting held on February 14th in the Municipal Auditorium was addressed by Mr. Steve Smith, Flame Hardening Specialist, Air Reduction Sales Company, who spoke on "Flame Hardening." The talk was illustrated with slides and a colored motion picture on flame hardening, gear teeth, lathe ways and other operations.

LOS ANGELES

The Annual Stag Party of the Los Angeles Section was held at the La Rumba Club on December 15th. About 75 members and guests were present.

The regular meeting of the Section was held on January 19th in the Commercial Club Bldg., Los Angeles. There were 115 members and guests in attendance for the dinner, with approximately 200 in attendance for the meeting afterward. Two very interesting talks were heard. The first by Dr. W. D. Theisinger, Welding and Metallurgical Engineer, Lukens Steel Company, on "Practical Research in the Welding Shop," and the other by Mr. J. F. Lincoln, President, The Lincoln Electric Co., on "Welding *vs.* Prejudice."

MILWAUKEE

A National President's Night was held on Friday, January 27th in the City Club of Milwaukee. An after-dinner talk was given by Russ Winnie, Asst. Manager, Radio Station WTMJ, Milwaukee, who talked on "Sport Broadcasting."

Mr. Harry C. Boardman, President of the Society and Research Engineer, Chicago Bridge and Iron Co., in whose honor the meeting was held, presented an address on "Large Field-Welded Tanks of Cylindrical, Spherical and Spheroidal Shapes."

MONTANA

A dinner meeting to celebrate the Third Anniversary of the Montana Section was held in Glasgow, Montana, on January 6th at the Coney Island Cafe. The program of the evening consisted of a paper by Mr. H. C. Boardman, President of the Society, on the subject of "Large Steel Welded Tanks." This paper was illustrated with 64 slides.

The February meeting was held in Fort Peck on the 2nd. Mr. A. M. Candy, Consulting Engineer for the Hollup Corporation, presented an interesting paper on Welding—Past, Present and Future." The paper was read by the Chairman and was illustrated with slides. The paper brought out many interesting facts and there was a fine discussion.

The March meeting will be held in Fort Peck. A paper will be prepared and read by Mr. W. P. Gray of the U. S. Engineers Department.

NEW YORK

A meeting of the AMERICAN WELDING SOCIETY, New York Section was held on Tuesday, February 7, 1939 at 7:30 P.M., in Room 501, Engineering Societies Building, 33 West 39th Street, New York, N. Y. Mr. J. T. Phillips, Superintendent, Boiler Shop, Foster Wheeler Corporation and 2nd Vice-Chairman, New York Section, A. W. S. presided. Mr. Ira T. Hook, Research Engineer, The American Brass Company, was the speaker and gave a very comprehensive lecture on "High Spots in the Welding of Copper Alloys." His talk was accompanied by a number of interesting lantern slides. Approximately 85 persons attended the meeting.

AMERICAN WELDING SOCIETY DAY NEW YORK WORLD'S FAIR

The New York Section, A. W. S. is happy to announce that the New York World's Fair officials have agreed to designate a day, during the latter part of May, the exact date to be set later, as "AMERICAN WELDING SOCIETY DAY." They have generously consented to furnish the A. W. S., a headquarters in one of their buildings on the Fair Grounds, and to supply uniformed guides to conduct A. W. S. members and their guests in groups on tours of the various exhibits and spectacles throughout the day.

In the evening, the New York Section of the AMERICAN WELDING SOCIETY will hold a get-together dinner in a restaurant on the Fair Grounds, which it is hoped all Members of all Sections of A. W. S., who are present at this reunion will attend, and bring their friends with them. Ladies will be welcome. Well-known speakers and other events planned are expected to make this a gala event.

Be on the lookout for further announcements as soon as final arrangements have been completed and plan to attend this outstanding occasion.

NORTHWEST

Mr. M. S. Clark, President and General Manager, The Federal Machine & Welder Co., addressed the members of the Northwest Section at its regular monthly meeting January 25th in the Minnesota Union, University of Minnesota, on the subject of "Latest Developments in Resistance Welding." Mr. Clark's Talk was extremely interesting and held the undivided attention of all those present.

Motion pictures showing the 1938 Minnesota football team in action proved an added attraction.

The increasing interest in welding is indicated by an "Institute in Welding" February 9th, 10th and 11th, conducted by the Institute of Technology of the University of Minnesota, under a planning committee. The purpose of the course was to present the technical design problems of welding. The course was built around five basic subjects, namely: metallurgy, metallography, design, testing and economics of welding. The total cost for each registrant was $6.00.

Mr. C. E. Swift, Welding Engineer, The American Brass Co., addressed the February 15th meeting on "Welding Copper and Copper Alloys," which talk was illustrated by lantern slides.

"Steel—Man's Servant," a sound technicolor motion picture produced for the United States Steel Subsidiaries, was also shown.

OKLAHOMA CITY

In addition to the regular monthly meeting held January 10th, and which has been previously recorded, the Oklahoma City Section was otherwise quite active during the same month, having held three special meetings in a lecture series.

The meetings were held Tuesday, Wednesday and Thursday, January 17th, 18th and 19th.

The meetings were confined to members only, and the interest in the subject was made manifest by the splendid attendance.

The first meeting was on the subject of "Arc Welding," with R. L. Looney, of the Big Three Welding Equipment Company of Tulsa, giving the lecture and supervising the demonstrations which followed. The subject was divided into four essential parts—primary requirements, preparation of work, type of joint and the welding arc.

"Acetylene Welding" was the subject of the second lecture given by M. F. Dunne, of the Air Reduction Sales Company, Oklahoma City. This lecture was also divided into four principal parts, the same as the preceding one, with the exception that the last portion dealt with the welding flame. Demonstrations of acetylene welding were made, and as in the preceding lecture, those in attendance were invited to try their hand at the actual welding operation.

For the third lecture, a sound motion picture furnished by the Taylor-Winfield Corporation was presented, this film showing the application of cutting and welding in the fabrication and construction of large and heavy mechanical equipment.

The meeting held on Tuesday, February 7th, was another of the enjoyable dinner meetings, with interesting entertainment following the dinner.

Through the courtesy of the Republic Steel Company, a sound film showing the manufacture, fabrication and numerous applications of "Enduro" was presented.

Mr. T. R. Lichtenwalter, of the Metallurgical Department of the Republic Steel

Company, added to the information given by the picture, and through direct answers to many questions, those in attendance learned much concerning the welding and the uses of stainless steel.

The Section has been invited to take an active part in the welding conference and short course presented by the University of Oklahoma on March 9th and 10th under the supervision of William Tiffin, of the Engineering staff of the University.

PEORIA

Mr. K. L. Hansen, Consulting Engineer for the Harnischfeger Corporation, Milwaukee, and inventor of the Hansen Welder, lectured on "The Electric Arc as a Welding Tool" at the February first meeting of the Peoria Section.

PHILADELPHIA

The regular monthly meeting of the Philadelphia Section was held on February 20th in the Engineers' Club. Mr. Charles H. Jennings, Director of Welding Research of the Westinghouse Electric and Manufacturing Company, spoke on the subject "Residual Stresses."

The following is the program for the next few meetings of the Section.

March 20, 1939—8:00 P.M., Engineers' Club, Philadelphia, "Structural Design and Welding," by F. H. Frankland, American Institute of Steel Construction, Inc.

April 17, 1939—8:00 P.M., Engineers' Club, Philadelphia, "Steel Casting and Plate Fabrication," by C. W. Briggs, Steel Foundries Assn. of America. (Joint Meeting with American Foundrymen's Association).

May 1939—Annual Inspection Trip.

PITTSBURGH

Approximately 150 members and guests attended the February 15th meeting of the Pittsburgh Section in the Mellon Institute to hear Mr. Frederick H. Dill, Assistant to Mechanical Engineer, American Bridge Company, speak on "Designing for Structural Welding."

Mr. H. L. Seaman, Superintendent, Bureau of Buildings, and John J. Murray, Engineer in the same department of the City of Pittsburgh, discussed Adoption of Welding in the Building Code.

The next regular meeting of the Pittsburgh Section will be held March 15th, at the same location, at which time Mr. George Mikhalapov of the Heintz Manufacturing Co., will present a paper.

ROCHESTER

The February meeting of the Rochester Section was held on the 2nd in Todd Union, University of Rochester, River Campus. The meeting was preceded by a dinner. Mr. T. R. Lichtenwalter of Republic Steel Corp., spoke on "The Welding of High Chromium and Chromium Nickel Stainless Type Alloys."

The March meeting held on the 13th was a joint meeting with the Rochester Chapter of the American Society for Metals. The speaker was Mr. Leo Edelson of Handy and Harman, and his subject was on "Silver Brazing Alloys."

The annual election of officers of the Rochester Section will be held on May 4, 1939.

SAN FRANCISCO

The regular monthly meeting of the San Francisco Section was held on January 20th in The Athens Athletic Club, Oakland. "Pipe Welding and Welding Fittings" was presented by Mr. G. L. Morrill, Manager of the Pacific Coast Division of the Midwest Piping & Supply Co., Inc.

The February meeting was held on the 3rd in the Assembly Room, Russ Building, Dr. W. G. Theisinger, Metallurgy Expert, with the Lukens Steel Company, talked on the subject "Recent Developments in the Metallurgy of Welding."

SAN JOAQUIN VALLEY

Mr. J. C. Blake, Vice-President, The Victor Equipment Company, Welding Equipment Division, was the Guest Speaker at the January 27th meeting of the San Joaquin Valley Section. Mr. J. C. Blake's presentation of his paper on "Automatic Electric Welding" was of considerable interest.

ST. LOUIS

The regular monthly meeting of the St. Louis Section was held on Friday, February 10th in the Engineers' Club Auditorium. Mr. W. J. Chaffee, Territorial Manager, Welding Division, Hobart Brothers, presented an address on "Steel Houses Completely Built and Equipped in the Factory."

Mr. H. T. Potts, President, St. Louis Shipbuilding and Steel Company, addressed the March 10th meeting on "Arc Welding as Applied to Construction of Steel Hulls."

The following is the program for the next few meetings of the Section:

April 14, 1939—"Modern Trends in Oxy-Acetylene Design, by N. A. Schmidt, Engineering Dept., Modern Engineering Co.

May 12, 1939—"Distortion Problems," by Chas. H. Jennings, Research Engineer, Westinghouse Elec. & Mfg. Co.

June 9, 1939—Annual dinner meeting and entertainment.

TULSA

In an effort to secure more members among the operator class the Tulsa Section put on the following program on Monday, February 20th, in order that prospective members might see what the Section is doing. A Free Dutch Lunch for members and prospective members preceded the program of events. A talk on Codes and Qualification Tests was given by Mr. F. J. Thompson of the National Tank Company, Tulsa. A discussion on Welding of Alloys Prevalent in Local Area was made by Mr. Forrest Hoffman of the Tulsa Boiler & Machinery Corp. Mr. C. L. Wiley of the Mid-Continent Petroleum Corp. spoke on Welding all types of Refinery Equipment, which was followed by an open discussion by all those present.

WASHINGTON, D. C.

A regular meeting of the Washington Section was held on January 24th, at which over 100 members and visitors heard a talk on the "Non-Destructive Testing of Welds" by Mr. N. L. Mochel, Metallurgical Engineer of the Westinghouse Electric & Mfg. Company This timely subject aroused considerable interest and was well received.

The Section, on February 8th, was also favored by Mr. C. H. Jennings, Research Engineer of the Westinghouse Electric & Mfg. Company, with a most interesting talk on "Welding Design." This Technical Meeting was well attended and thoroughly appreciated by all those present.

WESTERN NEW YORK

The Western New York Section held its regular monthly meeting January 26th at the Statler Hotel. The speaker was Mr. Ira T. Hook, Engineer of the American Brass Company. His subject was the Welding of Copper and Its Alloys. In spite of the extreme cold weather there was an attendance of approximately sixty.

Mr. Hook gave a very interesting talk on the subject. The audience expressed great interest and asked a great many questions.

The February meeting was held on the 23rd. Dr. A. B. Kinzel of the Union Carbide & Carbon Res. Labs., spoke on "Low Alloy Steels for Welding Applications."

WICHITA

A very satisfactory meeting of the Wichita Section was held on January 27th. A short musical entertainment preceded the introduction of the speaker of the evening.

The speaker, Mr. M.V. Burlingame, District Superintendent, Natural Gas Pipeline Company of America, presented a motion picture of the construction of a 980 mile 24 inch natural gas pipeline which operates at above 700 pounds pressure. Explanation was made during the course of the picture. Mr. Burlingame gave a very interesting talk afterward relative to the operation and maintenance of the line and brought out the important part welding played in making this line and its operation possible. A lively and educational discussion followed. The meeting was a decided success and the attendance was about sixty.

YOUNGSTOWN

The February meeting of the Youngstown Section was held on the 7th in the Ohio-Edison Auditorium. Mr. D. H. Corey, Welding Engineer of The Detroit Edison Co., spoke on the subject "High Pressure, High Temperature Piping."

OBITUARY

The Balbach Company, Omaha, Nebraska announces with deepest regret the death of Colonel Oscar E. Engler, president and general manager of this company Saturday, February 11, 1939.

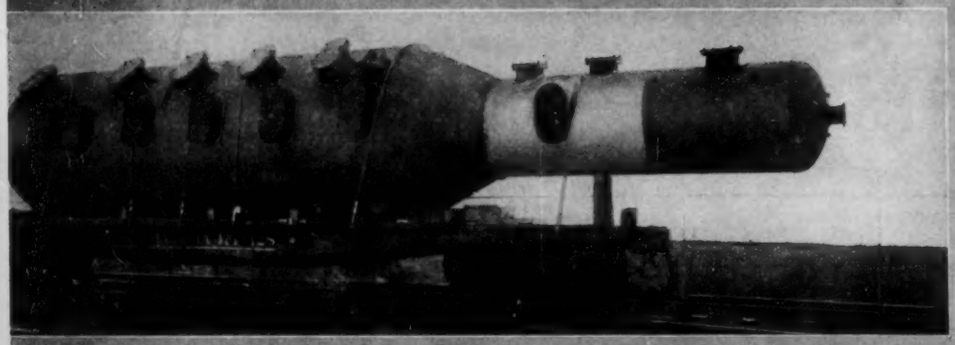
"PRODUCTION INCREASED—WELDING TIME SAVED" SAY SCORES OF CASE HISTORIES

In case after case, where Murex Electrodes have gone on the job, users report important savings in welding time, increased production, and lower welding costs.

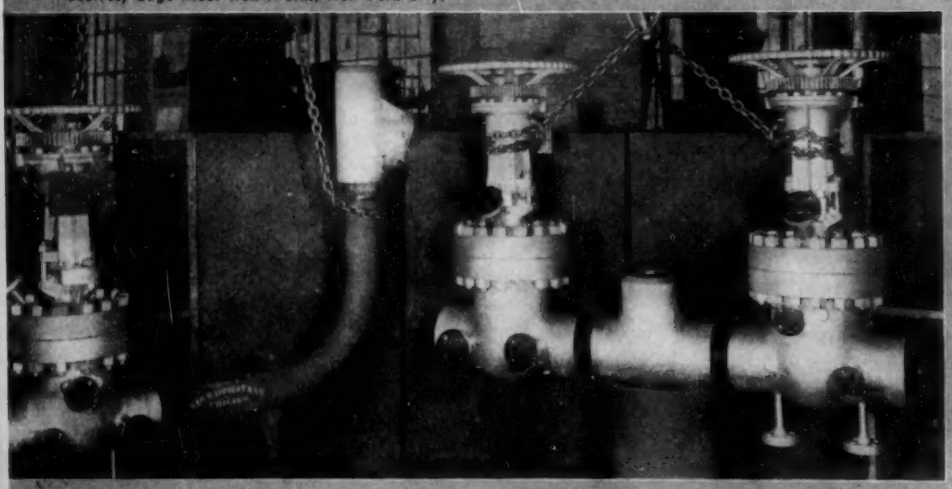
And, with all the economy of Murex Welding, there's never a sacrifice in quality. The Murex line includes electrodes that give sound, X-ray clean deposits, that assure beautifully smooth neat welds, that meet every requirement for strength and ductility.

Write, now, and ask to have our representative demonstrate the Murex Electrode most suited to your needs. At the same time, make use of his broad experience. Let him lend a hand on your welding problems. There is no obligation whatever.

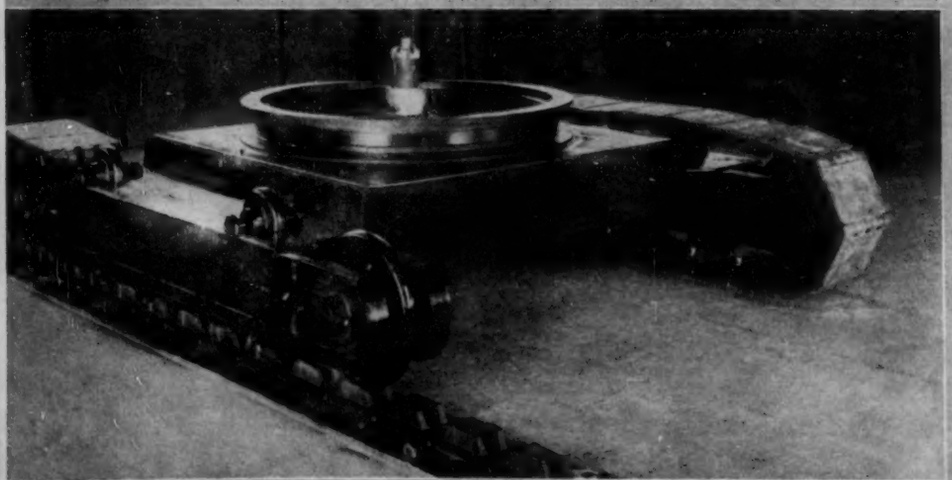
Ask, too, for the handy, pocket-size Murex pamphlet giving information on applications and properties of twenty different Murex Electrodes.



1 "It's easy to qualify welders with Murex," says one manufacturer. And that saves money for makers of oil refinery equipment like this fractionating tower, built to A.P.I.-A.S.M.E. standards. *Photo courtesy Edge Moor Iron Works, New York City.*

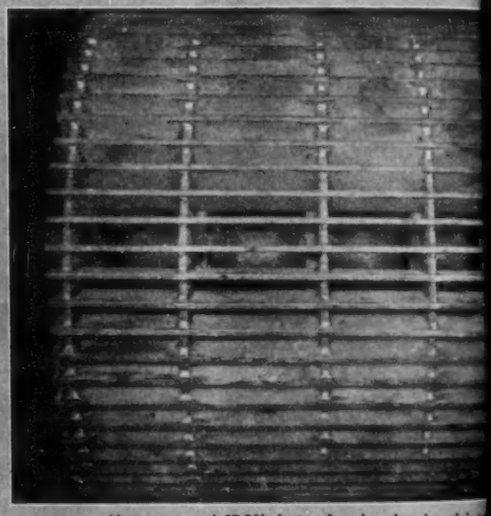


2 Production of fabricated piping was speeded 100% in one Michigan plant—a job that took hours is now done in minutes. *Photo courtesy George B. Limbert Co., E. Chicago, Ind.*



3 Quarter inch fillets are made in 30% less time since using Murex at a leading Pennsylvania fabricator's. Such savings are important in production jobs like the welding of this shovel bed. *Photo courtesy The Hanson Clutch & Machinery Co., Tiffin, O.*

4 Reports from plant after plant say welders prefe[r] because smooth clean deposits and easy-to-remo[ve] save time and trouble. *Photo courtesy Blaw Knox Co[.] Knox, Pa.*



5 Murex proved 37.5% faster for downhand work in [a] by a large Detroit manufacturer. Think of the sa[v]ings means in building complicated structures requiring [hun]dreds of feet of welding. *Photo courtesy United Welding Co., [Ste]ubenville, O.*

MUREX

HEAVY COATED

ELECTRODES

METAL & THERMIT CORPORATION

120 Broadway, New York, N. Y.

Albany • Chicago • Pittsburgh • So. San Francisco